

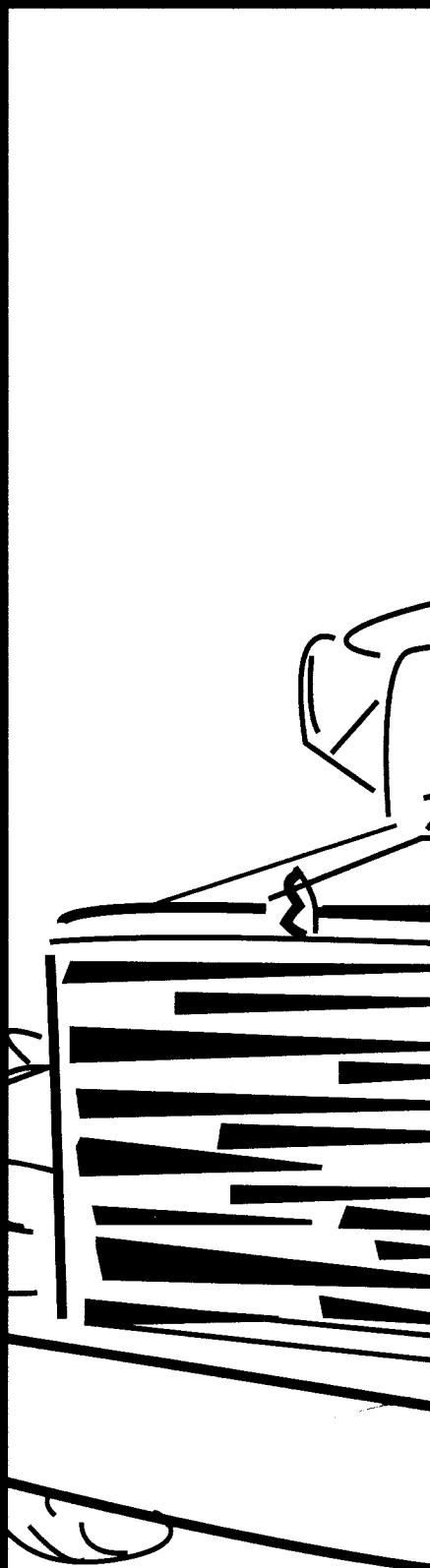
AMERICAN
TRUCKING
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Understanding Fatigue and Alert Driving

INSTRUCTOR MATERIALS

*In Partnership with the
Federal Highway Administration
U.S. Department of Transportation*



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Foreword

These course materials provide resources for a four-hour presentation on truck driver fatigue and how to reduce its effects in the interests of highway safety. The content is based on a broad review of existing literature on fatigue in general and its influence on commercial vehicle safety in particular. This course is designed to *educate instructors on the nature and prevention of fatigue*. Since instructors must have a deeper understanding of the phenomenon of fatigue than class participants, and an understanding of fatigue is based on technical definitions and processes, this course is by necessity much more technical in content than the courses that will actually be delivered to drivers, dispatchers, and other audiences. These course materials are provided separately for each audience category, and are directed specifically to the needs of those audiences.

The objectives of this course are to enable attendees to (1) define fatigue as a physiological and psychological phenomenon and explain its particular effects on trucking safety; (2) discuss the magnitude of the truck driver fatigue problem, including a reconciliation of the wide range of estimates and their effects on public perceptions; (3) explain the interaction of sleep, circadian rhythms, and life style on the occurrence and control of truck driver fatigue; and (4) apply a knowledge of fatigue and related topics to a discussion of measures that can be taken to reduce the danger of fatigue to highway safety.

Topics include the nature of sleep and the circadian rhythm, and their interaction with fatigue; chemical aids to sleep and wakefulness, including their effects, their advantages and disadvantages, and their safe use; and proved countermeasures to fatigue.

This course was developed by STAR MOUNTAIN, Inc. under contract to the ATA Foundation as part of a broad program of fatigue outreach to selected segments of the trucking industry under a Cooperative Agreement with the Federal Highway Administration's Office of Motor Carriers. Principal authors of the course are:

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The authors gratefully acknowledge the assistance of many contributors and reviewers in the development and completion of this project, including Dr. William C. Rogers of the ATA Foundation and Mr. David J. Osiecki of the ATA Safety Department and staff of the Office of Motor Carriers, Federal Highway Administration.

Understanding Fatigue and Alert Driving: Instructor materials

This instructional package supports a course designed to provide a broad understanding of truck driver fatigue for instructors. The information presented here is selected and delivered to support education *of potential instructors for focused fatigue courses* to be delivered to primary audiences: supervisors, dispatchers, safety managers, risk managers, and drivers.

Course objectives

After completion of this course, the attendees will be able to:

- **Define fatigue as a physiological and psychological condition, and explain its particular effects on trucking safety.**
- **Discuss the magnitude of the truck driver fatigue problem, including a reconciliation of the wide range of estimates, and their effects on public perceptions.**
- **Explain the interaction of sleep, circadian rhythms, and life style on the occurrence and the control of truck driver fatigue.**
- **Apply a knowledge of fatigue and related topics to a discussion of measures that can be taken to reduce the danger of fatigue to highway safety.**

Instructional format

This is a four-hour course that relies principally on interactive lecture and discussion. Instructors may vary the format with group exercises or other devices as suggested by the instructor's level of experience and the characteristics of the attendees. Instructor notes include practical comments and suggestions for class conduct, and supporting materials and class notes are provided for students.

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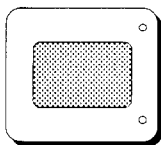
How to use these lesson materials

This package contains the following elements:

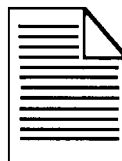
1. **Instructor materials.** The most important part of the instructional package is the instructor materials, which include a topic-by-topic outline of the class, content and sequence of subjects, insertion points for slides, videotapes, and handouts, approximate required time for each section, and advisory notes for the instructor. This is the principal “lesson plan” to be used for instructional delivery.
2. **Student materials.** Along with the instructor materials, there are several student handouts that will be issued to provide “take-home” resources for attendees, as well as feedback for the instructor(s).
3. **Instructor references.** The instructor materials provide neither a script nor an in-depth resource, particularly for technical topics. A number of expanded written discussions and supplemental publications are provided to allow the instructor to learn the details, depth, and practical examples needed to present a successful course.
4. **Instructional media.** The lesson materials are supported by a set of 47 slides and a video tape.

Using the instructor materials

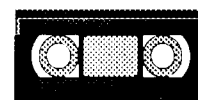
The left hand column of the instructor package (“instructor notes”) provides information on *how the lesson should be presented*. Included are instructional media and activities represented by icons and text notes, and brief descriptions of the instructional strategy and practical pointers on delivery and class management. The following icons are used:



Slide



Written materials



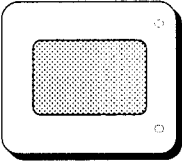
Video tape

The illustration on the following page identifies the format features of the instructor materials.

Section heading

What is fatigue?

Slide icon



Slide number

5. What is fatigue?


Approximate presentation time

[10 min.]

Instructor hints

Explain how a poor understanding of what fatigue *is* can complicate understanding, measuring, and regulating the circumstances that affect fatigue and determination of countermeasures.

Document icon



Consult instructor reference on fatigue and truck driving.

Fatigue is a state of mind and body; our response to continued physical or mental activity. Fatigue is characterized by

- *Both mental and physical effects.*
- *diminished ability to do work, including loss of attention, slower reactions, poor response, deterioration of judgment, vigilance, and alertness, and other problems;*
- *subjective feelings of tiredness, loss of motivation, a lethargic mood, a desire for rest or sleep.*

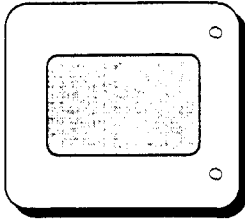
There are some things that fatigue is *not*.

- *Fatigue is not hours of service.* Depending on complex circumstances, we may be over strict hours of service, but not fatigued (though we are more likely to be). We may also be fatigued even if we are *under* HOS limits.
- *Fatigue is not simply falling asleep; you can experience the effects of fatigue while awake.* The effects of fatigue begin to take hold long before we are actually nodding at the wheel.

Lesson topics, sequence, and

Instructor Notes

Lesson Presentation

**Opening Activities****1. Title****[5 min.]**

Welcome participants to the course and introduce yourself. Give a brief description of your background, emphasizing subject matter expertise. Introduce any visitors.

Welcome and introductions**[3 min.]**

Explain the purpose of the instruction: To establish the importance of fatigue and its effects to the safe operation of a commercial vehicle; to highlight the most important factors that contribute to fatigue; to discuss and the most common myths about fatigue effects; and to suggest useful countermeasures.

Administrative information

Explain that feedback from participants is needed on the appropriateness of what is being taught to the audience; *personal experiences are a good vehicle for understanding.*

Discuss the training schedule.

Q&A**[3 min]**

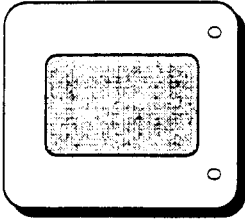
Answer any administrative questions participants may have. If necessary, orient the participants to

*Instructor Notes**Lesson Presentation*

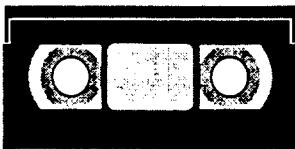
the facilities available at the training site, such as where to go for access to phone or fax machine, and where the lavatories and fire exits are located.

Instructor Notes

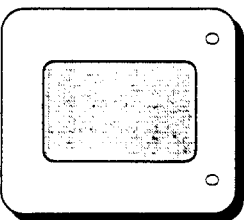
Lesson Presentation

**2. Course overview****[5 min]**

Introduce the course with a brief overview of the main topics to be covered.



Show video tape: "Fatigue — What You and your Family Should Know"

**3. How serious is the problem?****[10 min.]****Course Overview**

This course will help you answer the following questions, as well as apply these answers to your jobs:

- *How serious is the problem?*
- *What is fatigue?*
- *How does fatigue affect alertness and performance?*
- *How do sleep and fatigue interact?*
- *How do health and fatigue interact?*
- *How can we control fatigue and maintain alertness?*

Introductory video

This short video provides an overview of the material to be presented in this class.

How serious is the problem?

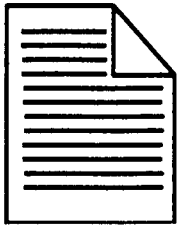
There have been many efforts to estimate the size of the truck driver fatigue problem. Recent studies of highway crashes related to driver fatigue include:

- *AAA Foundation (1985): 41% of crashes involving trucks that were serious enough for a vehicle to be*

Instructor Notes

The magnitude of the fatigue problem may be of interest to certain audiences, and may be reviewed if the specific lesson materials suggest. Since questions may arise, instructors should understand at least the reasons for the wide variance in estimates.

Discuss the various estimates of the influence of fatigue in crashes involving large trucks. Emphasize the problems involved in estimating crash causes and the differing assumptions that yield such a wide range of estimates.



Consult instructor reference 1 on fatigue incidence estimates.

Lesson Presentation

towed away were alleged to involve fatigued truck drivers.

- *NTSB (1990): 31% of crashes that involved large trucks and were fatal to the truck driver.*
- *NTSB (1995): Studied only a small number of single-vehicle truck crashes in which the driver survived.*
- *NHTSA (Knipling & Wang, 1994): Concluded that information in accident reports indicated fatigue was involved in 1% to 4% of all vehicle crashes; hard to estimate the true proportion.*
- *NHTSA (Knipling & Wang, 1995): Drowsiness or fatigue as a “discernible causal factor” in 1.2% to 1.6% of crashes, inferred from police accident reports (PARs). Stated this was probably an underestimate.*

Why the wide variance in estimates?

- **Assumptions are different.** For example, the NTSB estimates were based on single vehicle roadway departure (SVRD) large truck crashes. Such crashes are by their nature disproportionately likely to involve fatigue. These reports were never intended to be an estimate of the overall size of the problem, but are sometimes cited out of context.
- **Low end figures are probably underestimates,** because of the difficulties inherent in establishing crash causes after the fact; dead drivers cannot be interviewed; live ones may not always admit they fell asleep at the wheel; etc.

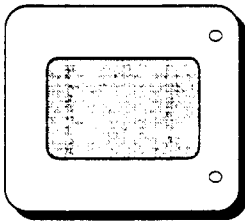
Instructor Notes

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- **Fatigue can be a primary cause or a contributing factor.** Analyses do not always identify the contribution of fatigue unless it is the principal identified factor.

Conclusion: *There is a problem with fatigued truck drivers on the highway; its exact extent cannot be established from available crash report information.*

Why study truck driver fatigue?



4. Why study truck driver fatigue?

[5 min.]

Explain why, given the uncertainty of the problem's size, we should devote so much time and energy to truck driver fatigue.

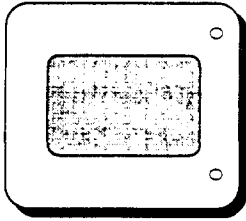
- **Trucking is a 24-hour business — concern for safety demands that we study fatigue.** As we shall see later, working at night even when we are not technically fatigued can cause performance and safety problems.
- **There is public concern that sleepy drivers may cause highway accidents.** There are a lot of myths making the rounds about fatigue and trucking operations, and we should try to understand what the truth is.
- **Truck drivers (and others) can be injured or killed in fatigue related crashes.** Whatever the real rate of truck-involved, fatigue related crashes, people die. In fact, it is likely that many crashes fatal to the truck driver are *single-vehicle crashes that may be fatigue related.*
- **Fatigue affects your driving performance even if you don't fall asleep at the wheel.** Fatigue affects your ability to do many important things even while you are awake: it

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degrades your attention to important events, slows your driving responses, alters your judgment, and causes driving problems long before you actually go to sleep at the wheel.

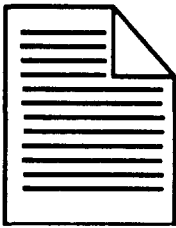
- ***Such accidents can be catastrophic and lead to loss of revenue for carriers, employers, shippers, and truck drivers and their families.*** A fact we often ignore: the surest way for a truck driver to die is in single-vehicle roadway departure crashes, not in collisions with other vehicles. These events (SVRD crashes) often involve driver fatigue.
- ***If cited or fined, drivers risk losing the CDL and their livelihoods.*** Is making that last run on time worth losing a livelihood?
- ***Highway safety can be improved by understanding and combating driver fatigue.*** We should not drive if we are fatigued, and we should understand how to prevent it and to fight its effects.
- ***Controlling driver fatigue and maintaining alertness can improve productivity.*** Good safety performance lowers operating costs; besides being a good idea on the personal level, it is also good business.
- ***Wellness, quality of life, and family lifestyle of truck drivers can be improved by identifying and preventing loss of driving alertness and fatigue.***



5. What is fatigue?

[8 min.]

Explain how a poor understanding of what fatigue *is* can complicate understanding, measuring, and regulating the circumstances that affect fatigue and determination of countermeasures.



Consult instructor reference 2 on fatigue and truck driving.

What is fatigue?

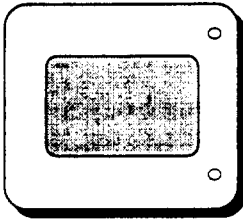
Fatigue is a state of mind and body; our response to continued physical or mental activity. Fatigue is characterized by

- *Both mental and physical effects.*
- *diminished ability to do work, including loss of attention, slower reactions, poor response, deterioration of judgment, vigilance, and alertness, and other problems;*
- *subjective feelings of tiredness, loss of motivation, a lethargic mood, a desire for rest or sleep.*

There are some things that fatigue is *not*.

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- *Fatigue is not simply falling asleep; you can experience the effects of fatigue while awake.* The effects of fatigue begin to take hold long before we are actually nodding at the wheel.

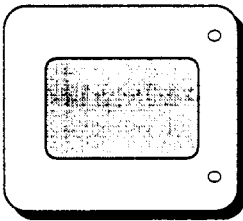
Instructor Notes



6. Causes of fatigue

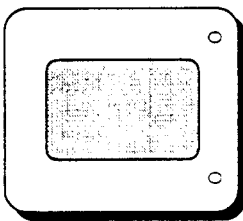
[3 min.]

Class participation is useful at this point. Probe the participants for examples of fatigue and driving performance or safety considerations from their own experience.



7. Acute and chronic fatigue

[1 min.]



8. Physical fatigue

[5 min.]

It is vital to help participants

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- Fatigue may result from **inadequate rest, sleep loss and/or disrupted sleep**, from **stress**, from **displaced biological rhythms**, **excessive physical activity such as driving or loading**, or from **excessive mental or cognitive work**. *Cognitive work* includes such activities as thinking, reasoning, and decision making.

- Acute** (short term) fatigue can be relieved by adequate rest or sleep. **For example:** When we have been driving for several hours and begin to feel tired, a short break at a truck stop or a night's sleep, depending on the circumstances, can provide relief.
- Chronic** fatigue from repeated and cumulative stress (like burnout) is not usually alleviated by rest alone, but to restore alertness requires an extended break, such as a vacation or a holiday.

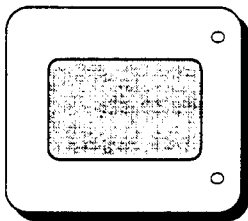
What is physical fatigue?

We are most concerned with general or mental fatigue; however, physical and mental fatigue interact, and we need to keep in mind the effects of physical exertion. Physical fatigue is characterized by:

- A **temporary loss of muscle power** to respond to demands, induced by continued stimulation (e.g., eye fatigue,

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differentiate between fatigue that is specifically physiological and the more generalized fatigue which is of greatest concern to truck drivers.



9. General or mental fatigue

[8 min.]

Most of the examples and background in this class will address *general fatigue*. While physical fatigue (such as from loading or unloading a truck before driving) may contribute, most of the critical performance effects result from general fatigue, due to extended length of time working and loss of sleep.

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muscle fatigue from strenuous activity)

- **A feeling of muscular tiredness**, soreness, body aches, or other discomfort
- **A decrease in physical performance** (for example, a driver who is too tired to load a truck efficiently)
- **May have mental components** (muscular fatigue and performance can be affected by what the brain tells us). It is important to understand that physical fatigue can be influenced by how we feel psychologically. Sometimes when our muscles are very tired, our mental motivation may override physical fatigue and we can call up extra effort to get the physical task done. **This is not the same as general or mental fatigue.**

What is general or mental fatigue?

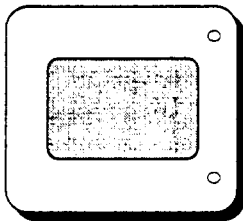
We are mostly concerned in this class with **general fatigue**, which we usually experience as drowsiness or sleepiness. The following factors characterize general fatigue:

- **A feeling of weariness after hours of repeated performance**, particularly of tasks that are not as physical, for example, a very long day at work, whether busy or not.
- **Monotony and boredom** (e.g., driving on a long stretch of highway with little change in scenery or arousal level).
- **Mental fatigue is more pronounced**, and our alertness level decreases, if

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we are already tired and drowsy due to loss of expected sleep. An important point that cannot be overemphasized: if we are used to sleeping at night, but our schedule suddenly requires us to drive during the time our body expects to be asleep, we are likely to suffer the symptoms of fatigue *even if we have not been working very long.*



10. Factors affecting fatigue

[8 min.]

It is vital to understand that fatigue does not usually develop from a simple cause-effect sequence. Elicit class discussion as time permits, including personal experiences of these effects.

These points are not always obvious; they should be reinforced by examples that will connect theory with the audience's experience.

Other factors that may affect fatigue

- **Prior sleep quantity and quality before beginning a set of tasks.** A good night's sleep can work wonders; there is really no effective substitute.
- **Individual physical fitness.** Generally, better fitness allows us to stay alert better; this is why soldiers and professional athletes train for physical fitness.
- **Endurance, how accustomed the individual is to level of workload or task demands.** Our level of energy and resistance to fatigue are increased when we are experienced at meeting task demands.
- **Environmental conditions** (temperature, humidity, altitude, amount of light, noise, other factors). If the weather is hot and humid, we tend to be drowsy; bright light and noise tend to keep us awake. Thinner air at high mountain altitudes makes us tire more easily.

In addition, such conditions as fog, rain, or snow may so increase the

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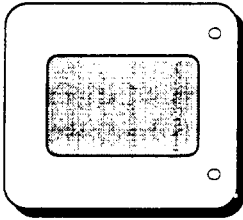
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demands for attention and response that the effects of fatigue may be more dramatic.

- **Number of sustained work episodes.**
Working on tasks nonstop can easily result in fatigue faster than if the work is intermittent, the workers control the pace, or there are breaks. A change in activity can give performance a quick boost — but only to a point.
- **Time of day the task is performed.**
The mid-afternoon and the very early morning make performing more difficult; this is because of the natural effects of circadian rhythms, which we'll discuss later.
- **The kind of task being performed.**
Tasks that demand constant attention (like driving) can cause fatigue faster than self-paced work, in which a person can stop and take rest breaks at will.
- **Workload.** How hard we work, and whether the work is continuous or intermittent, can make a difference.
- **Motivation and other individual differences.**

Class Break

[10 min.]



11. States of sleep

[2 min.]

This section is difficult to teach because it is necessary to understand the nature of sleep (quality v. quantity), and because understanding how we describe sleep requires at least some understanding of how the brain works (neurophysiology) and how we measure its activity (electrophysiology).



Consult reference 3 on the physiology of sleep.

What is sleep?

To understand how fatigue builds and why it affects us as it does, we must understand something about sleep.

States of sleep

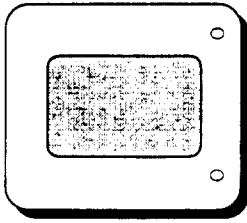
There are two *states* of sleep: REM and NREM (non-REM).

- **REM** (rapid eye movement) sleep, which is the state during which we do most of our dreaming, is characterized by **fairly active mental and physiological functioning** in the brain and by **dreaming**. The skeletal muscles are involuntarily relaxed (sleep paralysis, which prevents us from walking around to act out our dreams), but the muscles that move the eyes are active and the eyes can actually be seen moving behind closed eyelids.
- **NREM** (non-REM) sleep is characterized by **slowed mental and physical activity** and may be **light sleep** or very **deep sleep**. We may toss and turn in NREM sleep (but not in REM), but we will not usually dream, and the characteristic NREM brain wave patterns are different from those of REM.

REM and NREM sleep alternate through approximately 90-minute periods or cycles of sleep as the person shifts cyclically through the several stages of sleep.

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**12. Sleep stages and brain waves****[5 min.]**

This material is technical and nature, and generally need not be presented to all audiences. Since quality of sleep is defined by sleep stages, and sleep stages are defined by characteristic brain waves, instructors should have some familiarity with this material.

Frequency of electrical signals such as brain waves is expressed in Hertz (Hz), pronounced “hurts.” One Hz = 1 cycle per second.

Slide 12 is a complicated slide that illustrates complicated concepts. If you are going to present this material in your class, make certain you understand the slide before you try to explain it (see *The Physiology of Sleep*), and walk the attendees through the slide “by the numbers.”

Sleep stages and brain waves

The nature and quality of sleep are defined by measuring the kinds of electrical activity on the surface of the brain.

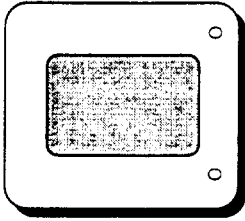
There are four *stages* of NREM sleep, associated with characteristic **brain wave patterns** and “depth” of sleep. These brain wave patterns are caused by electrical activity in the brain that can be measured using scalp electrodes, electrical amplifiers, and a special measuring apparatus called an **electroencephalograph** (EEG).

The **stages of sleep** are defined by characteristic brain wave patterns. Stages 1 and 2 are “light” sleep, whereas stages 3 and 4 are relatively “deep.”

- **Stage 1** sleep occurs shortly after we go to bed, and recurs periodically afterward through the night. At first, the brain exhibits high-frequency (10 Hz)/ high amplitude activity electrical signals called **alpha waves**.
- Then alpha signals decrease and episodes of very high amplitude, high frequency (12-16 Hz) signal bursts called **sleep spindles** occur. This is **Stage 2** sleep.
- After about 15 minutes of Stage 2, very slow 1-2 Hz activity begins, signaling **Stage 3** sleep.
- The predominance of slow waves identifies **Stage 4**, the “deepest” level of sleep.
- **In REM sleep**, the brain wave activity

is similar to that of a **fully-awake brain**.

Humans normally cycle repeatedly through these stages during the period of sleep. These cycles usually repeat about every 90 minutes throughout the night.



13. How much sleep is enough?

[5 min.]

This is a key set of concepts, and there are frequent misconceptions. Make certain the learners understand that the *packaging* of sleep changes, not necessarily the amount.

How much sleep is enough?

There is no simple answer to this question, because:

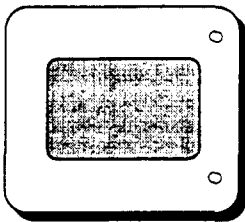
- **Sleep requirements vary with age;** teenagers, for example, require more sleep than most of us — as much as 9-10 hours per night.
- **There are individual differences.** Two drivers of the same age may have different sleep requirements to feel rested and alert.
- **People over 50 “package” sleep differently.** Sleep packaging changes — particularly for REM sleep, which declines as we get older.
- The requirement for sleep doesn’t go away, and it can’t be satisfied except by sleeping. The more sleep we have lost, the more likely we are to suffer the effects of fatigue.

Most adults feel most rested and perform best with 7-8 hours of uninterrupted sleep. The word “uninterrupted” is important. Eight hours of disrupted sleep are comparable to getting too little sleep; *eight one hour naps do not provide the same quality of sleep as eight uninterrupted hours of solid sleep.* All the sleep stages have functions; if we are not

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asleep long enough to cycle through the stages, we will not have obtained enough restful, restorative or recuperative sleep. This is an important consideration, which we will discuss shortly.

**14. Sleep loss and sleep debt**

[5 min.]

Do *not* convey the impression that recovery sleep = naps. While the recovery of sleep debt is not on an hour for hour basis, actual sleep is required to pay off the debt.

Sleep loss and sleep debt

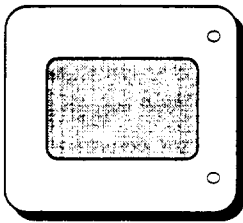
Occasionally, we can perform well after only 4-5 hours of sleep in a 24-hour period. But after one or two days of this, we build up what we call a **sleep debt**, and begin to perform as if we have missed an entire night's sleep.

- **If we miss sleep, we build up a “sleep debt.”** That is, if we normally function well with eight hours of sleep per night, and then for each of five days, Monday to Friday, we only obtain six hours of sleep per night, we have lost two hours per night, and in one week build up a sleep debt of *10 hours*. This is a loss of more than a full night's sleep, and we frequently perform as if we had actually missed one night's sleep.
- **Missed sleep or sleep loss adds up and results in a cumulative sleep debt.** Like food and water, sleep is a fundamental physiological need; sleep is necessary to survival.
- **Sleep loss and the sleepiness that results cause affects our performance, makes us likely to make mistakes, and can affect our mood.**
- **Sleep debt is repaid by “recovery sleep.”** As our practical experience informs us, this is not necessarily a

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simple “1 for 1” replacement; recovery sleep — physiologically and psychologically restorative sleep — needed to replace sleep lost may often be shorter than the actual number of hours we missed. When we finally pay off a heavy sleep debt, our sleep is usually deeper, only moderately longer, than ordinary sleep.

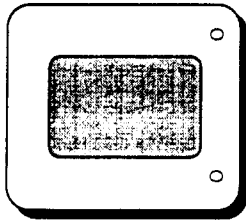
**15. Sleepiness components****[2 min.]****Sleepiness has two distinct components.**

- **Physiological sleepiness is similar to hunger and thirst:** Our bodies need a steady intake of fluids; when we feel thirsty, we are already partially dehydrated. At this point, we no longer perform at our best, and we gradually decline. If we deprive ourselves of sleep, we are not as alert; we must get regular sleep to maintain that alertness balance and not build up a sleep debt. In short, the body signals a need (sleepiness). Just as this can only be satisfied by water, this need can be satisfied *only* by sleep.
- **Subjective sleepiness is the driver's own assessment of his or her state of alertness.** It can be affected by environment (amount of traffic, for example, or the radio), conversation, or interventions like taking in caffeine. **These factors may momentarily improve our alertness, but they do not affect the underlying sleep deficit; they only affect our perception of it.**
- **Other subjective factors.** People generally fall asleep faster and sleep longer than they estimate. They are

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also likely to be sleepier or less alert than they believe or report.

**16. Rest and sleep**

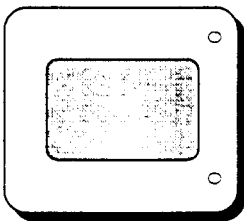
[2 min.]

Rest and sleep

Rest and sleep are not the same. We can rest, merely stop working — “veg out,” watch television, read a book, or just lie around relaxing — but this is not a substitute for sleep. To understand why this is so, we must understand what sleep is and how it is structured.

The Circadian Rhythm

Discussion of the circadian rhythm is crucial to understanding the effects of fatigue on trucking operations. The circadian cycle is the most important single factor that affects fatigue and performance; it is present and influential *even when a driver is not technically fatigued*. When it interacts with fatigue, the results can be deadly, and when schedules upset the rhythm, fatigue is a likely outcome. *Knowing how the circadian rhythm operates can help drivers understand their limits and take action to counter fatigue effects.*



17. The circadian rhythm

[3 min.]

Most drivers or others in the class will have a first-person understanding of the difficulties that accompany frequent schedule changes.

Review background summary *The Physiology of Circadian Rhythms*.

Important points to emphasize:

- Performance is affected by circadian rhythms even if we have not been driving for long hours.
- Through circadian rhythms, time of day interacts with fatigue.
- If you understand your natural cycle, you have an important tool for predicting and countering the effects of fatigue.

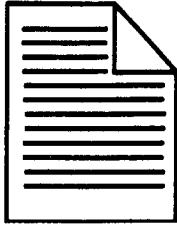
The circadian rhythm: introduction

As the tape illustrates, most drivers have experienced severe fatigue associated with after-midnight, boring stretches of highway as well as an afternoon wave of sleepiness or grogginess.

This fatigued feeling is a reflection of an internal biological clock cycle called the **circadian rhythm**, a factor that has profound effects on our alertness and driving performance in truck operations.

In short, our bodies have an innate approximate 24-hour biological rhythm that is reflected by shifts in body temperature (lowest in the pre-dawn hours and in the mid-afternoon), mood, motivation, and performance. **This is of great importance to truck drivers, whose jobs often require long stretches of driving at times**

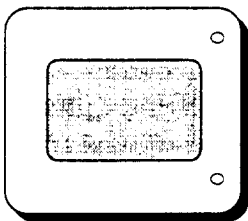
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Consult instructor reference 4 on the physiology of circadian rhythms.

More important than any other point:

The “down” periods of the circadian rhythm occur whether we are fatigued or not. Fatigue will make the effects worse, and safety problems influenced by fatigue are more likely to occur during the “down” part of the cycle, but driver performance will be poorer at these times even for nominally well-rested drivers.



18. Circadian rhythm: facts

[5 min.]

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when their bodies “want” them to be asleep.

This slide shows a common measure of circadian rhythm — body temperature — over a period of 2 ½ days. Note that there are two important features:

- Body temperature (and other measures we will discuss in a moment) goes down significantly during the night and early morning, particularly in the last hours before dawn (midnight to 4 AM). Circadian effects can intrude during this period *even if you do not feel fatigued*.
- Temperature levels off or declines slightly in the mid afternoon before picking up again in the late afternoon and evening.

This rhythmic cycle is an evolved biological mechanism. Humans developed the circadian rhythm that made us essentially a day/night species long before we developed 24-hour commercial activities.

The circadian rhythm: facts

- The circadian (a word from Latin *circa die* — “about a day”) cycle is an evolved mechanism — an internal biological clock. It coordinates the physiological priorities for daily activities, including body temperature, hormonal secretion, digestion, performance, and other variables. Circadian rhythms affect alertness, mood, motivation, and performance; the effects of these rhythms are *highly resistant to schedule changes*. That is, the brain and the body are so

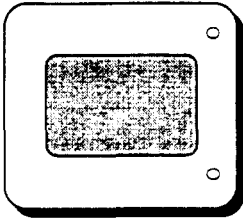
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accustomed to repeating the same functions at the same times each day that they resist adaptation to changes in the work schedule.

- **The principal trigger for setting the biological clock to a 24-hour day is the presence of bright sunlight.** Other regularly scheduled activities, such as meal times, work schedules, bed times, and social schedules contribute significantly to determining our 24-hour body rhythms. Other factors may intrude or disrupt those rhythms: shift work, for example, may influence our ability to keep the cycle stable. The point is, when we find ourselves working when we would normally be asleep, our bodies “fight” us. And when we work odd hours, our natural circadian rhythms get “off track.”
- **Circadian clocks are not adjusted as easily as we reset our watches** (“jet lag” illustrates this). Rotating shift workers rarely adapt to one work/rest schedule before they shift to another schedule (e.g., work days), then the midnight shift, then the swing shift. This causes a condition similar to “jet lag” called “shift lag.” The clearest implication for truckers: do not shift to a “day” cycle when you go off work.

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**19. Circadian “low points”****[2 min.]**

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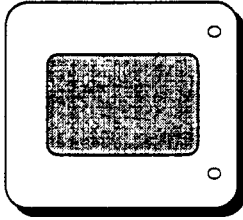
Circadian “low points”

If we are awake at our circadian low points — that is, 2-4 PM and the midnight-to-4 AM period — we tend to experience a decline in performance (slower reactions, errors, etc.), as well as a parallel decline in mood and motivation.

During our circadian low points, we experience the following:

- A general lull in mid-afternoon (about 2-4 PM) and especially in the very early morning (about midnight-4 AM). (These periods correspond to a decline in body temperature and other physiological changes.)
- When we work during a circadian lull, particularly in the early morning hours, our performance is usually affected by our circadian rhythm *even if we are not fatigued*.
- Decreased response rates and mental performance.
- Decline in mood and motivation.
- Increased sleepiness and reports of fatigue.

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**20. Factors that affect the circadian rhythm****[3 min.]**

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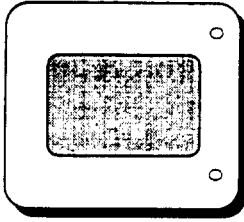
Factors that affect the circadian rhythm

The normal flow of circadian rhythms can be affected by a number of circumstances, among them:

- **Flying across time zones.** The body attempts to catch up with the clock time of our destination time zone.
- **Shift changes.** This is particularly true in a “backwards” clock change, as when we change from an 8 to 5 schedule to a midnight to 8 (“shift lag”).
- **Drug use.** Many prescription and non-prescription drugs and chemical compounds affect our circadian rhythms.
- **Bright lights,** like sunlight, reset our circadian clock.
- **Sleep loss** increases the effects of circadian “lows,” increases the probability that we will make mistakes and suffer lower performance.

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**21. Effects of circadian disruption****[4 min.]**

Participants can provide first-person support for each of these symptoms; they are part of the fabric of life and work. In this case, anecdotal evidence can be compelling and can bring the class into the learning process. We are all experienced “experts” on fatigue.

Effects of circadian disruption

When the cycles of our circadian rhythm become disrupted — for example, through changes in driving schedules, particularly those that make us drive through circadian low points — we often experience physiological and psychological difficulties. **The effects of the circadian low points will be magnified if we are already fatigued.**

If our circadian rhythm is disturbed (that is, gets out of phase), the “normal” circadian decline is exaggerated, potentially causing a variety of symptoms:

- **Disturbed sleep/inability to fall asleep.** We cannot “make” ourselves go to sleep. If we are “off cycle,” sleep is difficult to obtain. Even if we are tired, there is a tendency to be awake in the morning because this is an “active” part of the body’s natural cycle when the body temperature is rising. A common problem: the brain *wants* us to be awake from nine to eleven in the morning, whether we’re sleep-deprived or not. Likewise, most of us will not be asleep at about 6 PM, when the body temperature has resumed its rise after the mid-afternoon lull.
- **Increased sleepiness.** This can occur at any time, depending on the severity of sleep loss or disruption; it is most dramatic during the circadian “lull” phases (for example, 2 to 4 PM and midnight to 4 AM).
- **Decreased mental performance.** Even before recognizable signs of drowsiness appear, performance may be

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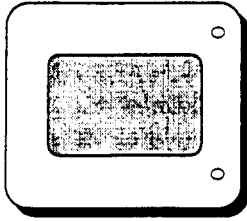
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affected, particularly vigilance, response time, alertness, and cognitive functioning.

- **Increased reports of fatigue.** The subjective experience of feeling fatigued by itself may affect performance, affect motivation and job focus.
- **More negative mood.** Fatigue due to circadian disruption can cause changes in the motivational state. Depression, irritability, and other undesirable symptoms that affect productivity, safety, and teamwork can appear.
- **Gastrointestinal problems.** Digestive processes are regulated by circadian rhythms. Disruption of the biological clock and changes in eating habits causes disruption of the digestive processes (e.g., stomach acid does not arrive at a time when the body expects us to eat food; because of the schedule change, the acid only creates discomfort and potential damage). At least some of the gastrointestinal symptoms attributed to generalized stress come from this source.

Many shift workers in a variety of professions have persistent complaints of gastrointestinal problems (e.g., diarrhea, gastritis, peptic ulcers, and other digestive problems).

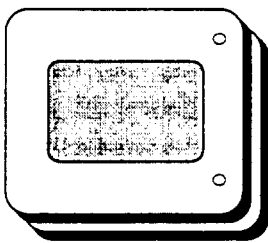
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22. What affects our ability to adjust to circadian changes?

[5 min.]

It is worthwhile to remind attendees that, just because a thing is held to be true in general, it is not necessarily true in specific. Some older people may be more tolerant of schedule changes than some younger ones.



23-24. Owls and larks

[3 min.]

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What affects our ability to adjust to circadian changes?

The circadian rhythm and its effects can be influenced by a variety of factors.

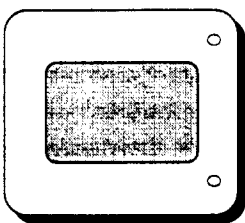
- Different people adapt at different rates to changes in schedule. Some are fairly flexible and resistant to changes in work/rest schedule and “shift lag,” while others show the effects dramatically and require more time to recover.
- The level of resistance to circadian disruption tends to decrease with age; in general, people over 50 are less tolerant of changes in schedule, and take longer to adapt to shift changes.

Owls and larks

People seem to have different preferred activity times; we sometimes use the terms “owl” and “lark” to describe two distinctly different work schedule preferences.

- **Larks** are “morning people,” and insist that they perform best in the early morning (5-11 AM) and believe they do not do well later in the day. They prefer to go to sleep early in the evening and wake up early in the morning. Larks tend to see themselves as early birds, and as highly productive, and wonder why other people are not like them. There is a modest amount of biological evidence that people who perceive themselves as larks tend to have more highly rigid circadian systems, and that their rhythms tend to resist changes to new work schedules. They often have problems with jet lag and shift lag.

- **Owls** insist they perform best late in the day (11 AM to 4 PM) and believe they do not do well earlier in the day. They often stay awake late at night, tend to have more flexible sleeping habits, and if they call into play their high motivation, are more apt than larks to *believe* they readjust rapidly to sudden work schedule changes like shift rotations.
- Behavioral scientists dispute whether owls and larks perform measurably better or worse according to their stated preferences. But they recommend that we acknowledge the individual preferences, and suggest that larks' and owls' preferences be accommodated in assigning work schedules.
- Truck drivers may want to discuss with driving team members and dispatchers which of them is an owl and which is a lark, and might also discuss this with their spouses and family members to help arrange sleeping schedules and general life styles



25. Night work and the circadian rhythm

[3 min.]

Night work and the circadian rhythm

There are recognized problems with night work and circadian rhythm effects.

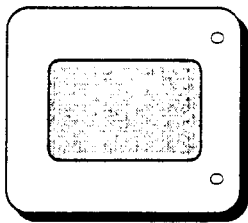
- **Working at night requires adjusting our circadian clock.** Adaptation of body and brain to a change in work shift does not happen quickly — in fact, physiologically it may require up to three weeks lag time. Frequent shift changes (like weekly changes in work schedule) can so disrupt our cycle that our bodies never really “catch up” and

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severe fatigue and many physiological problems can result.

- **People who work nights during the week tend to revert to daytime activity on weekends or on their scheduled day off**, effectively disrupting the body's adaptation to the new work schedule.



26. Sleep and trucking operations

[3 min.]

A possible discussion point to begin this section: Although drivers (like others who must function in a 24-hour economy) may adjust to schedules that run at cross-purposes to the circadian rhythm, it is not reasonable for the families to do so as well. During off-duty time at home, drivers will almost always have to revert to meet family social needs. This creates a risk of continual circadian disruption.

Ask for family life experiences if the audience is likely to respond to this problem.

The circadian rhythm and trucking operations

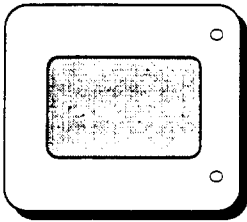
Truck drivers — particularly long-haul drivers — operate at all hours and this factor produces its own circadian rhythm disruption and fatigue problems. Duty at unusual or — in particular — changing times in the day/night cycle can lead to:

- **Conflicts** between duty schedules, environmental/local time, and “body time” (biological clock time).
- **Frequent circadian disruption.** Frequently changing driving schedules prevents the body from adapting to any circadian rhythm, contributing to fatigue and sub-par performance.
- **Extended duty periods longer than a normal duty day** result in prolonged wakefulness, fatigue induced by sustained or continuous operations, boredom, complacency, and all the other symptoms of disrupted schedule.
- **Restricted time available for sleep** results in **cumulative sleep debt** that can only be corrected by **adequate recovery sleep**.

Class break

[10 min.]

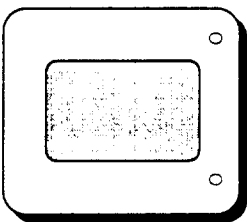
Chemical aids to wakefulness and sleep



27. Chemical aids to wakefulness and sleep

[1 min.]

Important point: Stimulants are not the answer, and we should not suggest they are. Only sleep meets our need for sleep. Differentiate between temporary coping measures and long-term practices that may do more harm than good.



28. Stimulant effects

[3 min.]

Surveys suggest that many drivers do not understand a great deal about chemical stimulants.

Emphasize safe use as a temporary measure, not as a “rubber crutch,” and

Truck drivers sometimes use chemical means to induce or suppress sleep. All these approaches have drawbacks, and before we use them we should be certain we understand how they actually work and what the “down side” is.

We will discuss common ways of staying awake when we feel sleepy, and ways to make getting to sleep easier.

As with all artificial ways of intruding on the body’s processes, sleep aids and stimulants should be used **correctly** and **only when necessary**.

Aids to wakefulness

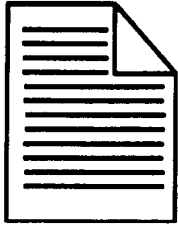
Stimulants of various types can help us maintain alertness even while fatigued, but there are drawbacks. *Some stimulants (such as amphetamines) are illegal except when prescribed, others are of doubtful value.*

Most important: No stimulant is a substitute for needed sleep.

- **Many chemical stimulants are illegal.** Others are available only by prescription.

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emphasize that many such substances are **illegal or are legal only when prescribed**.



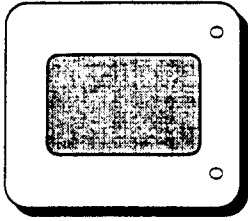
Consult instructor reference 5 on aids to sleep and wakefulness.

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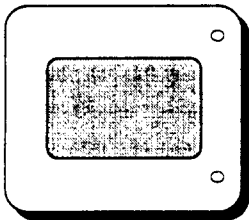
- **Stimulants (e.g., amphetamine, methylphenidate, caffeine, etc.) can extend performance when sleepy.** As we shall see, however, there is always a cost.
- **Stimulants cause a wide range of responses**, affecting both physiology and performance. For example, when using amphetamine, some drug users perform very well; but they often become so focused on a task that they do not stop performing, and thus they repeat a task behavior over and over when once would have sufficed.
- **There is often a rebound effect** of fatigue (in which you may become excessively tired) and mild depression after the stimulating effect wears off.
- **With all stimulants, there are damaging effects associated with repeated use and abuse.** This is certainly true of amphetamines and other well known psychoactive drugs which can be addictive. Even caffeine, if overused, can affect the heart and other physiological processes.
- Contrary to popular belief, **nicotine is not an effective stimulant**; it does not improve performance or alertness, and the smoke associated with tobacco makes you drowsy.

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**29. Caffeine effects****[3 min.]**

At this point, be sure to explain to the class that *adaptation* means that the body's physiology, after repeated exposure to something (such as caffeine) will usually stop reacting as strongly as it did when first applied. For this reason, we will eventually require larger and larger doses to experience the same effect.

**30. Sleep aid effects****[5 min.]**

Critical point: Circadian rhythms and other factors make us more or less likely to go to sleep at a given time.

Caffeine

Caffeine is probably the most widely used stimulant.

- **Caffeine can produce a relatively quick improvement in alertness.** For example, about 20-30 minutes after drinking 1 or 2 cups of caffeine-laden coffee, we will feel more alert. Caffeine affects the functioning of specific parts of the nervous system, interacting with the chemicals that normally govern nerve cell firing.
- Like most chemical interventions, **the body becomes adapted to the effects of caffeine**, and it becomes more difficult to obtain any helpful effects. After frequent and continued use, larger doses of caffeine are required to produce the desired effect. Thus, if you want caffeine to keep you awake, do not use it so regularly that it is not effective when you really need it. In any case, caffeine is not "curing" fatigue, but artificially suppressing its effects.

Sleep aids

Sleep aids (such as barbiturates, benzodiazepines, melatonin, and other "sleeping pills") are frequently used to induce sleep. Many are illegal, and all have drawbacks.

- **Most sleeping pills have serious limitations as aids to sleep as the body adapts to the drug's effects.** Frequent use can create a need for

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Sleep aids may not overcome this problem effectively.

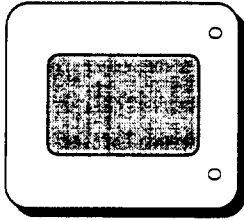
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higher and higher doses for the same effect.

- **Sleeping pills can actually *delay* the onset of sleep, disrupt normal sleep structure (i.e., the normal “cycle” discussed earlier), and alter our normal total sleep time.** Some sleep aids work better than others, some have serious side effects. No sleep medication is without drawbacks.
- **Barbiturates (such as sodium pentobarbital) were once widely used to induce sleep** (as well as for treating anxiety), but are strongly habit-forming and can be lethal in large doses. For this reason, they are not generally available.
- **Benzodiazepines are now used much more frequently than barbiturates.** Benzodiazepine drugs include well-known prescription medications like Diazepam, Lithium, Valium, Triazolam (Halcion), and Temezepam. They are not as strongly habit-forming and large doses are much less likely to be fatal.
- **Some sleeping pills may help drivers fall asleep,** and stay asleep, which upon awakening may improve alertness. But, like stimulants, the body may adapt to them and require higher and higher doses. When we stop using the sleep aids, the resulting withdrawal can make us even sleepier.

With some sleep aids, it is also very difficult to awaken from a drug induced sleep and respond quickly to an emergency — or to take your turn at the wheel safely. This is a phenomenon

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**31. Alcohol**

[1 min.]

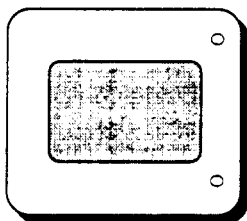
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called “sleep inertia,” which we will cover later.

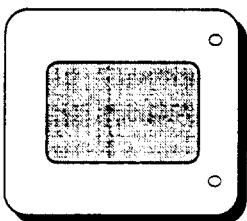
Alcohol

Some people try to use alcohol as an aid to getting to sleep as if it were a sleeping pill. But alcohol influences the type and quality of sleep we actually get.

- **Alcohol suppresses REM, leads to disrupted sleep and withdrawal effects.** For example, we may feel increased fatigue, depression, or headaches.
- **Alcohol can interact with sleep loss to increase drowsiness.**
- **Generally, alcohol is not a very effective sleep aid.**

**32. Melatonin: the good news**

[2 min.]

**33. Melatonin: cautions**

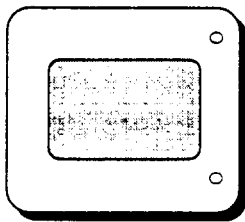
[2 min.]

Melatonin

- **Melatonin is a natural hormone** secreted in the body during darkness by the brain’s pineal gland. One of its functions seems to be to promote sleep at the proper times and to help control the body’s circadian clock.
- Current research suggests that **small amounts of Melatonin can be used to help us obtain quality sleep without the side effects of traditional sleeping pills.** It can be particularly helpful in synchronizing circadian rhythms after shift changes by helping to reset the internal “clock.”
- **However, commercially available Melatonin tablets sold in health food**

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Most of what is generally “known” about melatonin and its effects is distorted by marketing and imprecise news items. This point cannot be made too strongly.



34. Sleep disorders

[6 min.]



Consult instructor reference 6 on sleep disorders.

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stores contain *much higher doses than the body normally produces*, and are therefore probably too high a dose for work applications. More research is needed to understand the effects and to establish proper doses.

- **Medical research is also needed on the long-term effects of Melatonin use.**

Sleep disorders

Sleep disorders can disturb sleep and waking alertness. Sleep problems are not uncommon, and the resultant sleep loss and fatigue can have a devastating effect on performance in tasks that require continuous alertness (like driving a truck).

- **Insomnia** is a broad term for abnormal sleeping problems, and is associated with various psychological and neurological effects that make it hard for us to get enough quality sleep. Most people experience these sleep problems from time to time; they become a disorder when they occur with abnormal frequency or regularity, and when they affect performance.
- **Drug-dependency insomnia** occurs as a side effect of overusing sleeping pills. As we noted earlier, the body adapts to the chemicals in sleeping pills, requiring higher and higher doses to get the same effect.
- **Sleep apnea** is another cause of insomnia, and may be an important cause of truck driver sleepiness. People who suffer from apnea have episodes while sleeping during which their

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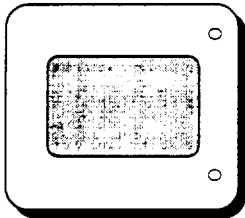
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breathing actually stops, an event that can cause severe disruption of sleep patterns. During breathing pauses, CO₂ builds up in the blood, triggering a reflex that causes the sufferer to awaken, gasping for air. This awakening can happen hundreds of times in a night. Though the sufferer is unaware of the episodes, the lost sleep affects performance and mood the next day. Apnea is particularly common among people who snore, and among the very overweight.

While there is presently no accepted cure for sleep apnea, *it can and should be diagnosed and treated with any of several acceptable medical approaches to control the problem.*

- **Restless legs syndrome (RLS)** is a feeling of discomfort in the lower legs that is relieved by kicking or stimulating the legs. People who suffer from RLS may have trouble getting to sleep or staying asleep. It is more common in older people (65 and older). RLS (and a related disorder called periodic limb movement disorder [PLMD]) can be successfully treated.
- Some people suffer from a disorder called **delayed (or advanced) sleep phase syndrome**. This is something like a portable “jet lag:” the sufferer experiences the effects of jet lag without going anywhere! This problem can sometimes be corrected by forcing 3-hour delays in sleep onset by going to sleep or staying awake later on successive nights until the circadian cycle is “reset.” (Sometimes this condition is a side effect of emotional depression.)

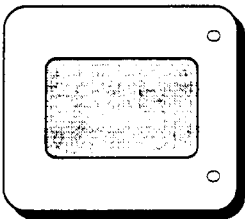
- **Narcolepsy** results from a variety of conditions, but is characterized by a sudden, involuntary urge to sleep. The result is a literal sleep attack, usually for 2 to 5 minutes.



35. Common misconceptions

[1 min.]

Combatting fatigue is a serious concern for truck drivers, and one of the biggest obstacles is the mythology of fatigue and sleep. It is helpful to deal with the misconceptions before suggesting better strategies.



36. "I know how tired I am."

[2 min.]

It may be useful to emphasize the comparisons between alcohol intoxication and fatigue. Many attendees will understand this quite well, and be able to apply it as a critical judgment factor on the job.

Misconceptions about fighting fatigue

There are some common misconceptions about fatigue and how to overcome it.

- **Misconception 1: "I know how tired I am."** The point is, you really *don't* always know. Some of the effects of fatigue begin to take hold before we are even aware of drowsiness. Remember: *fatigue is not the same as falling asleep* — that is, you don't have to be sound asleep for fatigue to affect driving.

One of the effects of fatigue is an impairment of judgment. Admitting you are tired is an act of judgment. Think of fatigue as a form of intoxication: as we can drink a few beers before we feel drunk, so we are fatigued before we feel the common signs of loss of alertness. If you *feel* fatigued, the process is already likely to be advanced, and you are *already* less alert

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than you think you are.

Remember also that, **unlike alcohol intoxication, the subjective feeling of fatigue can come and go.** We might shake off drowsiness for a *limited* time with a cup of caffeinated coffee or a short stretch break, but the underlying fatigue is still there.

Make certain that attendees understand that microsleeps are not simply short, unnoticed naps. When we are in microsleep, the eyes are open, but the brain waves are those of light sleep. In effect, “there is no film in the camera.” The information is coming in, but it is not registering.

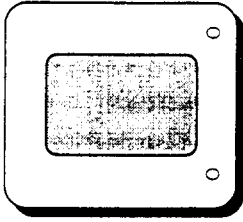
Another problem with knowing how tired you are is that, when fatigue is severe, we have actual lapses of response, during which our performance is effectively absent. These are associated with very short intermittent periods of **microsleep**, during which the eyes are open like those of an awake person, but the brain waves are those of Stage 1 sleep. The person’s reaction time is markedly slower, and he or she may therefore fail to respond, or commit errors of omission (miss a traffic signal, drift off the roadway). Microsleeps typically last no more than 1-10 seconds.

Microsleeps are unusual because the eyes remain open. As sleep loss becomes more severe, the frequency and duration of these intermittent lapses increases, and performance between lapses eventually becomes reduced.

If we experience a microsleep at a critical moment while driving, it could result in a crash.

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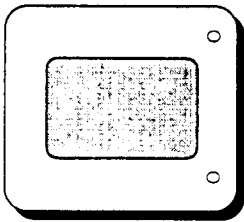
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37. "I've lost sleep before . . ."

[2 min.]

- **Misconception 2: "I've lost sleep before and I did just fine."** What you actually did was lose sleep and get lucky. Crashes are the result of complex factors, of which fatigue may be only one. You might not be lucky this time.

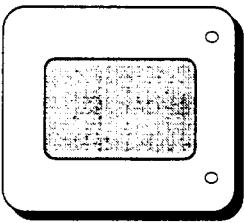


38. "I'm motivated enough . . ."

[2 min.]

- **Misconception 3: "I'm motivated enough to just push through it."**
Translation: I feel lucky tonight.

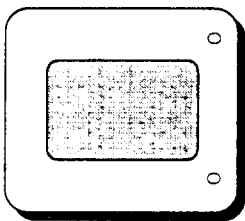
Remember: it is not easy to estimate reliably your own alertness and performance.



39. "There is a 'magic bullet' . . ."

[2 min.]

- **Misconception 4: "There is a quick fix for fatigue, a magic bullet."** An individual driver is a complex system, and a measure that seems effective at one time might not be effective at another. Multiply that times all the people who drive trucks, and the complexity is obvious. No single thing works in all cases.



40. "One cure will work . . ."

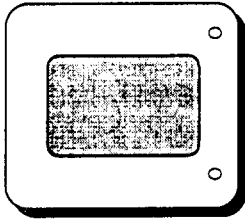
[5 min.]

- **Misconception 5: "One cure will work for all kinds of trucking."**
Different driving schedules, business environments, and wild-card factors like loading and unloading and waiting time at stops affect the kinds of countermeasures that are most effective.

It might be useful to note that there are research programs in progress or soon to start that examine the effects of fatigue in distinct operating environments of the trucking industry. These will be discussed in more detail later, but might be worth mentioning here.

Class Break

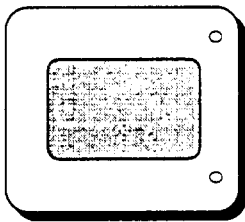
[10 min.]



41. Using fatigue countermeasures

[5 min.]

Emphasize these points; these are the most important lessons to carry home.



42. Preventive strategies

[5 min.]

Note that these strategies are not only the most important actions a driver can take, but also require the most planning, the most discipline, and the most knowledge of fatigue and of ourselves.

Fatigue countermeasures

The recommendations discussed in this class are not “magic bullets.” Tailor them to your own needs, combine them for the best effect.

There are two general strategies for preventing or combating fatigue:

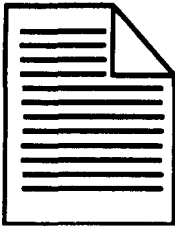
- **Preventive strategies.** These are used before duty and on layovers to reduce the adverse effects of fatigue, sleep loss, and circadian disruption during truck operations. These are decisions that rely on self-discipline, life style, and other variables.
- **Operational strategies.** We use these to maintain alertness and performance *while* we are on duty.

Preventive strategies

- **At home,** get the best sleep possible before starting a trip. You cannot store sleep, but it is most desirable to get about 8 hours of restful sleep before driving on a long trip.
- **On a trip,** try to get at least as much sleep per 24 hour period as you would get in a normal day at home.
- **Get your sleep at the right times.** Sleep is most likely to come, and most effective when it does come, at the times your body is most prepared for sleep. The best time is from midnight to six AM, when your body is in the lowest circadian phase; sleep from noon

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It might be useful at this point to lead a discussion on how to make the preventive strategies work (e.g., work/sleep calendars, planning for family activities, careful projection of shift or work schedule changes and their probable effects).



Consult reference 7 on sleep hygiene.

More detailed information is included in *The Alert Driver* on proper nutrition.

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to six PM is almost as good (again, at a circadian low period). From six to midnight is not preferred, but better than no sleep; worst of all is about six AM to noon, when our bodies *want* to be awake. Quality of sleep is likely to be lowest in this period.

- **Physical fitness and proper nutrition** are important in all areas of performance, including prevention of fatigue. This includes exercise, weight control, and proper diet.

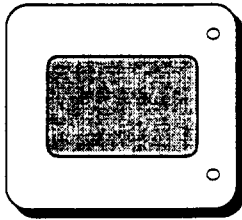
Remember: Obtaining restorative sleep is the *best* remedy for sleep debt. Sleep must be of a such a duration that all the sleep stages can have their time. A four-hour block of sleep, for example, will usually allow two REM cycles.

- **Trust your own body:**

If you feel sleepy, and if circumstances permit, get some sleep. If you *feel* sleepy, it is because you *are* sleepy; it's not likely to get better if you ignore it or try to "drive through it."

If you wake spontaneously and cannot get back to sleep within 15-30 minutes, get up. An hour of trying to get to sleep provides little or no restorative benefit. You may be fighting your own circadian clock. Try again when you are more poised for sleep.

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**43. Strategic napping****[2 min.]**

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- Use “strategic napping.”

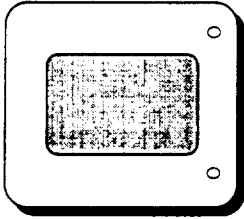
Before duty, a nap can improve alertness; **but:** limit nap to no more than 45 minutes. If you sleep long enough to go into a deeper stage, it may take longer for you to become fully awake. This is called **sleep inertia**, and can affect performance if we start to drive immediately after awakening. We have all experienced sleep inertia, that feeling when we have just awakened (particularly from a nap) and feel groggy, respond slowly and often inappropriately, and feel as if we are still in a dream.

Sleep inertia for some people can last for 15-20 minutes after we awaken. Some people are more likely than others to suffer sleep inertia.

To avoid sleep inertia, **plan ahead.** A nap can be longer than 45 minutes *if* you do not have to drive immediately after waking up. If your driving partner is subject to sleep inertia, awaken him/her 15-20 minutes before a shift in driving duties.

- Take naps at safe rest areas or private truck stops during long haul trips. Again, try to use naps of 45 minutes or less to avoid sleep inertia.
- Plan your route; preselect known safe rest stops and target them for your scheduled naps.

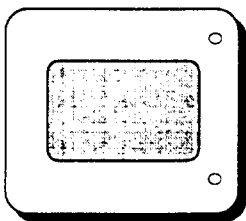
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**44. Good sleep habits****[2 min.]**

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Healthy, regular sleep habits can help prepare your body and mind and improve sleep quality.

- **Minimize disruptive factors.** (This may require cooperation by the family.)
- **Sleep in a dark, quiet room** (use heavy curtains if necessary).
- **Keep your bedroom at a comfortable temperature.**
- **Use a comfortable sleeping surface.** (Poor sleeping posture, such as curled up on a small sofa, may result in poor quality sleep — it may be difficult to get to sleep and to stay asleep.)
- **Develop a pre-sleep routine** so the brain anticipates sleep. Use your regular habits (e.g., brushing teeth, bathing) to prepare for bed.

**45. Operational strategies****[5 min.]****Operational strategies**

What to do to improve alertness while driving. THE BEST STRATEGY IS NOT TO DRIVE WHILE FATIGUED, BUT IF YOU *MUST* DRIVE:

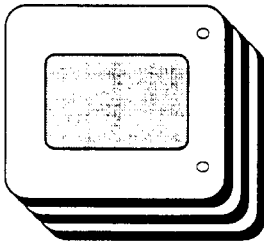
- **Engage in conversation** (passengers or CB). Follow the conversation on talk radio, or listen to broadcasts of sporting events. Play an entertaining or engaging audio tape.
- **Do something that involves physical action, such as arm, neck, and shoulder muscle exercises in the cab.**
- **Open the side window to get some fresh air.** This may help, but there is

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no strong evidence that this has much effect on alertness.

- **Don't smoke.** Remember, nicotine is not an effective stimulant, and smoke makes you drowsy.
- **Take frequent rest stops;** get out, walk around, stretch your muscles.
- **Change the routine.** The stimulating effect of a shift in activity can improve alertness for a while.



46-48. How do we recognize fatigue?

[5 min.]

How do we recognize fatigue?

Some signs of fatigue are clear, some are more subtle. In some ways, they are similar to alcohol intoxication. Signs of fatigue include:

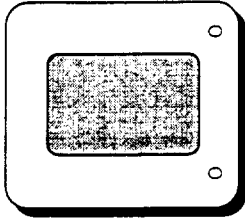
- **Drowsiness.**
- **Increasing desire to go to sleep.**
- **Frequent yawning.**
- **Loss of concentration and wandering thoughts.**
- **Head nodding, frequent blinking, shaking head to stay awake.** The eyes may shift in and out of focus, eye movements become less coordinated.
- **Slowed responses.** You may not react to events as quickly as when you are alert.
- **Inability to maintain attention.** Focusing on driving tasks may become difficult; you may even have problems

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following a conversation or listening to a radio talk show.

- **Loss of alertness.** We may suffer not only slow responses, but troubles in recognizing events we must respond to.
- **Slower decision making.** We may be slow to respond to the need to apply brakes to avoid cross traffic, etc.).
- **More frequent mistakes.** We are particularly likely to fail to do something we should have done, like leaving a turn signal on after the turn is complete.
- **Failure to follow instructions on road signs.** This is usually an indicator of lack of alertness.
- **Reduced awareness of surroundings.** For example, we may miss the presence of another vehicle until it is directly in front of us.
- **Random variations in speed.** We speed up and slow down and find it hard to maintain uniform speed.
- **Tendency to follow other vehicles too closely.**
- **Intermittent braking.**
- **Erratic shifting.** When fatigued, we may start to shift outside engine RPM ranges.
- **Lane deviations.** We may drift out of lane, weave, or encroach on the shoulder.

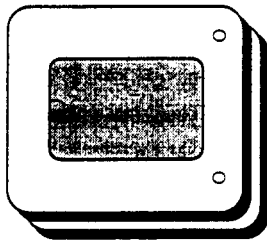
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**49. Using caffeine****[5 min.]**

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Using caffeine

- **Use caffeine when you need to increase alertness rapidly** and for a relatively short time. (With regular consumption, the effects of caffeine diminish over time; you can't stay awake indefinitely on coffee and other sources of caffeine, such as soft drinks or No-Doz.)
- **Don't consume caffeine when you are already alert**, as after a nap or at the start of a duty cycle. (If you drink a caffeine-containing beverage when you don't need the "jolt," its effectiveness when you *do* need it will be diminished.)
- **Avoid caffeine near bedtime.** Consuming caffeine will make it hard to go to sleep and may cause poor quality sleep (tossing and turning).
- **It takes more than caffeine to sustain you:** be sensible about nutrition, and stay hydrated with healthy fluids like water and fruit juices.

**50-51. Continuing fatigue study****[8 min.]****Continuing fatigue study**

We do not know everything there is to know about driver fatigue. There are still important **research initiatives** ongoing that may improve the effectiveness and practicality of countermeasures.

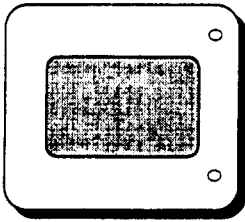
The National Highway Traffic Safety Administration (NHTSA) continues to evaluate vehicle-based drowsy driver detection measures. These programs stress development of capability for unobtrusively monitoring driver alertness (lateral steering inputs, lane position, etc.) and providing adequate warning.

Programs sponsored by the **Federal Highway Administration's Office of Motor Carriers** concentrate on the **operational environment** of the trucking industry. Studies in progress include:

- **Driver fatigue and alertness:** collecting driver performance and physiological data from 80 commercial drivers in a real-world environment.
- **Multi-trailer combination vehicle stress and fatigue.** Co-sponsored by FHWA and NHTSA.
- **Driver work/rest cycles.** A laboratory study of the effects of different amounts of sleep on driver performance.
- **Performance modeling of HOS alternatives.** Application of performance models to HOS and scheduling alternatives.

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- **HOS “re-start” focus groups and expert panel.**
- **Assessment of electronic on-board recorders for HOS compliance.**
- **Crash investigation project/crash causation study.**
- **Shipper involvement in HOS violations.**
- **Survey of scheduling practices and their influence on driver fatigue.**
- **Effects of loading and unloading on driver fatigue.**
- **Local/short haul driver fatigue.**
- **Fitness-for-duty testing.**
- **Sleep apnea research.**
- **Validation of eye and other psychophysiological measures.**
- **Sleeper berths and driver fatigue.**
- **Field test of technological countermeasures.**

**52. Keep in mind . . .****[5 min.]****Summary**

We should all understand certain basic things about fatigue.

- **Sleepiness and fatigue are serious threats to safety;** take them seriously. None of us can ignore fatigue and be a safe driver.
- **Physiological mechanisms underlie fatigue,** and psychological factors can affect how we feel when fatigued.
- **You can improve your ability to combat fatigue** while driving; plan your rest and sleep schedule ahead, use what you know from now on.
- **People differ in their susceptibility to fatigue;** one set of methods will not work equally well for all drivers.
- **There is no “magic bullet” for fatigue;** you must find the best combination of countermeasures that fits you best. Pay attention!

Understanding Fatigue and Alert Driving



Overview

- How serious is the problem?
- What is fatigue?
- How does fatigue affect alertness and driver performance?
- How do sleep, health, and fatigue interact?
- How can we control fatigue and maintain alertness?

How serious is the problem?

- AAA Foundation (1985): 41% of towaway accidents
- NTSB (1990): 31% of fatal-to-the-driver accidents
- NTSB (1995): Generalized 58% estimate
- NHTSA (1994): 1% to 4% of all crashes; probably an underestimate
- NHTSA (1995): 1.2% to 1.6% of PARs show fatigue as a “discernible causal factor”

Why study truck driver fatigue?

- Trucking is an around-the-clock industry.
- Public concern
- Potential for injury and death
- Affects performance even if you do not fall asleep.
- Loss of revenue
- Potential loss of CDL
- Potential improvement of highway safety
- Increased productivity
- Improved quality of life

What is fatigue?

- Fatigue is the body's response to continued physical or mental activity or sleep loss, characterized by:
 - diminished ability to do work, loss of attention, slower reactions, poor response, deterioration of vigilance and alertness, impaired judgment, and other problems;
 - subjective feelings of tiredness, loss of motivation, desire for rest
- Fatigue is *not* hours of service; fatigue is *not* simply falling asleep.

Causes of fatigue

- Inadequate rest
- Sleep loss and/or disrupted sleep
- Displaced biological rhythms
- Excessive physical activity
- Excessive mental or cognitive work

Acute and chronic fatigue

- *Acute* fatigue is a short term condition that can be relieved by adequate rest or sleep.
- *Chronic* fatigue results from repeated and cumulative stress, and may require an extended break, such as a vacation or a holiday.

Physical fatigue

- A temporary loss of muscle power to respond to demands.
- A feeling of muscular tiredness, soreness, or other discomfort
- A decrease in physical performance
- May have mental components

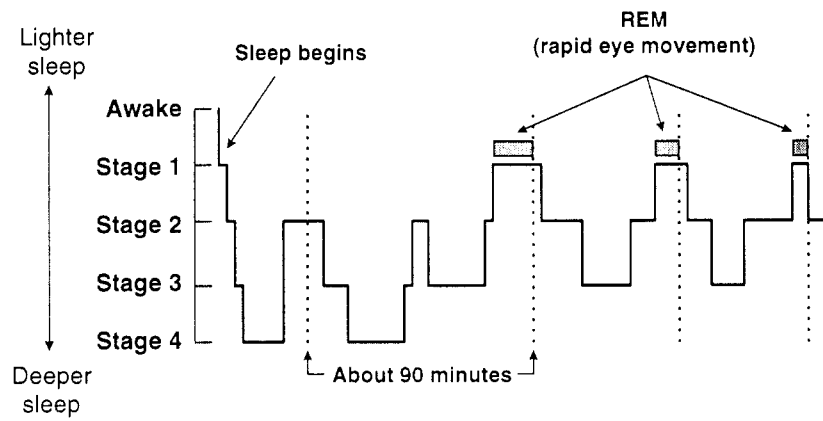
General or mental fatigue

- Subjective feeling of tiredness after extended or repeated performance, particularly of tasks that are not predominantly physical
- Feeling of monotony or boredom created by lack of novel stimulation
- Mental fatigue is more pronounced and our alertness level decreases if we are tired and drowsy due to loss of anticipated sleep.

Factors affecting fatigue

- Quality and quantity of prior rest
- Individual physical fitness
- Endurance, exposure to level of task demand
- Environmental conditions
- Number of sustained work episodes
- Time of day
- Type of task
- Workload (mental or physical)
- Motivation and other individual differences

States and stages of sleep



Sleep and brain waves

- Sleep is defined by *stages*.
- Each sleep stage (1-4) has characteristic electrical activity measurable in the brain.
- Each stage in order (1-4) is *deeper* than the one before.
- Between normal sleep and wakefulness is a state called REM (rapid eye movement) sleep.
- During REM, we experience active dreaming.
- During a typical night's sleep, we cycle through all four stages plus REM.

Rest and sleep

- *Rest* and *sleep* are not the same.
- *Rest* is a break or even a simple change of activity from a fatiguing task; we remain awake.
- Rest can restore energy, but it *cannot* substitute for sleep, nor can lack of sleep be corrected simply by resting.
- Sleep allows both body and brain to recuperate, to be restored and refreshed.

How much sleep is enough?

- Sleep requirements vary with age, and there are differences among drivers -- some need more sleep than others.
- Most adults perform best with 7-8 hours of uninterrupted sleep.
- Eight 1-hour naps are *not* the equivalent of a full eight hours of sleep.

Sleep loss and sleep debt

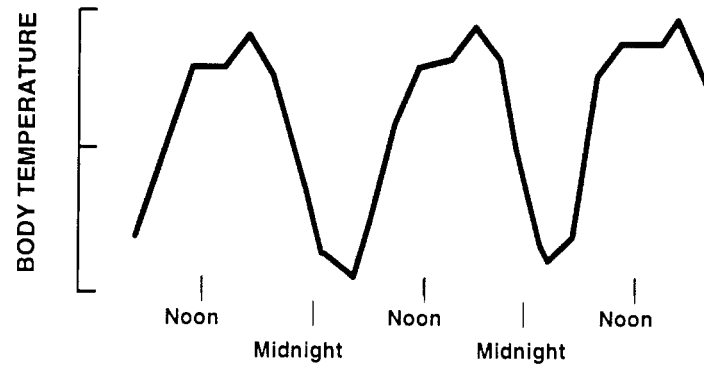
- Missed sleep or sleep loss is additive, and results in cumulative “sleep debt.”
- Sleepiness results in decreased physical and mental performance.
- We pay off sleep debt *only* by sleeping.
- Sleep debt requires “recovery sleep,” which is not a one-for-one replacement for missed sleep.

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Components of sleepiness

- *Physiological* sleepiness is like hunger or thirst: the body signals a need that must eventually be satisfied.
- *Subjective* sleepiness is the driver's own assessment; it can be affected by mental factors.

The circadian rhythms



Circadian rhythms: facts

- The brain's internal circadian "clock" coordinates daily cycles: sleeping/waking, body temperature, hormonal secretion, digestion, performance, and other variables.
- The circadian clock is reset daily by bright light (sunlight), work and rest schedules, and social interaction.
- The circadian clock cannot adapt quickly to such disruptions as sleep-work schedule changes.

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Circadian “low points”

- General “lull” in mid-afternoon and low point after midnight.
- Decreases in response rates and mental performance
- Decline in mood and motivation
- Increased sleepiness and reports of fatigue
- Working during a circadian lull can affect our performance *even if we are not fatigued.*

Factors that affect the CR

- Flying across time zones
- Shift changes
- Drug use
- Bright lights
- Sleep loss increases the effects of circadian "lows."

Circadian disruption

- Disturbed sleep/inability to fall asleep
- Increased sleepiness
- Decreased mental performance
- Increased reports of fatigue
- More negative mood
- Gastrointestinal problems

What affects our adjustment to circadian changes?

- Different people adapt at different rates to schedule changes.
- Level of resistance to circadian disruption decreases with age.

Larks

“Morning people:”

- have a strong preference for early morning wake-up times.
- believe they perform best in the early morning.
- believe they perform poorly as the day goes on and at night.
- tend to go to bed early at night.
- prefer to work day shifts

Owls

“Evening people:”

- prefer late morning awakening.
- believe they perform best late in the day and at night.
- tend to stay up quite late at night.
- prefer to work nights.
- Prefer to work day shifts

Night work and the circadian rhythm

- Daytime people who work at night must reset their circadian “clocks.”
- People who work nights during the week tend to revert to daytime schedules on weekends.
- Complete physiological adaptation to a new schedule can require 2-3 weeks.
- Periodic changes in shift schedule begin disruption in the circadian rhythm again.

Sleep and trucking operations

Trucking operations create sleep problems:

- Extended duty periods
- Restricted sleeping time (sleep debt)
- Conflicts between duty schedules and “body time”
- Frequent circadian disruption (schedule changes)

Chemical aids to sleep and wakefulness

Truck drivers frequently use artificial means to stay awake or to go to sleep. Stimulants and sleep pills are no substitute for proper sleep habits, and should be used *correctly* and *only when necessary*.

Stimulant effects

If you use stimulants to stay awake, remember:

- Some stimulants can extend performance, but not always productively.
- Stimulants cause a wide range of responses in physiology and performance.
- There is often a rebound fatigue effect.
- All stimulants can cause damage with repeated use and abuse.
- Nicotine is *not* an effective stimulant.

Caffeine effects

If you use caffeine to stay awake, remember:

- Caffeine is probably the most widely used stimulant, found in coffee, chocolate, some soft drinks, and in some medications.
- Caffeine can produce a relatively quick improvement in alertness.
- The body becomes adapted to caffeine; after repeated or excessive use, increased doses are required for the same effect.

Sleep aid effects

- Sleeping pills can have serious limitations as sleep aids.
- Sleeping pills can actually delay the onset of sleep and disrupt sleep quality.
- Barbiturates, once widely used, can be dangerous.
- Benzodiazepines (Librium, Valium, Diazepam, Halcion) are more commonly used and less dangerous.
- We may adapt to sleeping pills, and may experience withdrawal symptoms.

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Alcohol

- Alcohol is sometimes used as a sleep aid.
- Alcohol suppresses REM, leads to disrupted sleep.
- Alcohol can interact with sleep loss to cause drowsiness.
- Alcohol is not generally an effective sleep aid.

Melatonin: the good news

- A natural hormone secreted by the pineal gland during darkness.
- An endogenous (within the body) sleep-promoting agent.
- Permits quality sleep without the hangover effects associated with sleeping pills.
- Can help synchronize circadian rhythms.
- Can quicken adaptation to “jet lag” and “shift lag.”

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Melatonin: cautions

- Available tablets probably contain too high a dose for work applications.
- More research is needed to establish proper doses and appropriate use.
- Medical research is needed on the possible long-term effects of use.

Sleep disorders

- Insomnia (onset, maintenance, termination)
- Drug-dependence insomnia
- Sleep apnea
- Restless leg syndrome (RLS)
- Delayed (or advanced) sleep phase syndrome
- Narcolepsy (sleep attack)

Common misconceptions

- “I know how tired I am.”
- “I’ve lost sleep before and I did just fine.”
- “I’m motivated enough to just push through.”
- “There is a ‘magic bullet’ for fatigue.”
- “One cure will work for everybody.”

“I know how tired I am.”

- One of the effects of fatigue is impaired judgment, including judging how tired you are.
- The subjective feeling of fatigue comes and goes.
- Severe fatigue often causes lapses in performance (microsleeps).

“I’ve lost sleep before . . .”

(I’ve been lucky before.)

“I’m motivated enough . . .”

(I feel lucky tonight . . .)

“There is a ‘magic bullet’ . . .”

- Fatigue is hard to measure and control in a driver; effectiveness of fatigue measures will vary.
- No two drivers are alike.

“One cure will work . . .”

- There are many different trucking environments.
- Fatigue, and the appropriate countermeasures, vary with the job (loading and unloading at the site, waiting, scheduling, and other factors).

Using fatigue countermeasures

- *Preventive strategies:* Before duty and on layovers.
- *Operational strategies:* What to do while on duty to stay awake and alert.

Preventive strategies

- At home: get the best sleep possible before starting a trip.
- On a trip: try to get at least as much sleep as in a day at home.
- Get your sleep at the right times (at low circadian times).
- Don't forget physical fitness and nutrition.
- Trust your own physiology: If you *feel* sleepy, it is because you *are* sleepy.
- If you can't get to sleep within 15-30 minutes, get up and try again later.

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Strategic napping

- Before duty, a short nap (<45 minutes) can improve alertness.
- A longer nap carries a risk of *sleep inertia*, which can affect performance if we drive soon after awakening. *Plan ahead.*
- Plan to nap at safe rest stops during long hauls. *Be sure you are over sleep inertia before resuming your drive.*

Good sleep habits

- Minimize disruptive factors.
- Sleep in a dark, quiet room.
- Keep a comfortable room temperature (65°-70° F).
- Use a comfortable sleeping surface and a good sleeping posture.
- Develop a pre-sleep routine so the brain anticipates sleep.

Operational strategies

- Engage in conversation (passengers, CB, etc...), listen to talk radio.
- Stay active; stretch your muscles.
- Stop for frequent rest or exercise breaks.
- Open the side window for fresh air.
- Don't smoke: nicotine is not an effective stimulant, smoke makes us drowsy.

How do we recognize fatigue?

- Drowsiness
- Increasing desire to go to sleep
- Frequent yawning
- Loss of concentration and wandering thoughts
- Head nodding, frequent blinking, shaking head to stay awake

How do we recognize fatigue?

- Slowed responses
- Inability to maintain attention
- Waning alertness
- Slower decision making
- More frequent mistakes

How do we recognize fatigue?

- Failure to follow instructions on road signs
- Reduced awareness of surroundings
- Random variations in vehicle speed
- Following too closely
- Intermittent braking
- Erratic shifting
- Lane deviations

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Using caffeine

- Use caffeine for quick, short-term effect (for example, drink coffee 30 minutes before the desired “jolt.”)
- Don’t use caffeine when you are already alert.
- Avoid caffeine several hours before bedtime.
- *It takes more than caffeine;* be smart about nutrition and drink healthy liquids like fruit juices.

Continuing fatigue study

- Fatigue outreach training
- Driver fatigue and alertness
- Driver fatigue and stress
- Fitness-for-duty testing
- Sleep apnea research
- Rest and recovery
- Rest stop areas
- Loading and unloading effects
- Sleeper berth study

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Keep in mind:

- Sleepiness is a serious threat to driving safety.
- Fatigue is physiological, and can be affected by psychological factors.
- You *can* improve your understanding and your ability to combat fatigue.
- People differ in their susceptibility to fatigue.
- There is no “magic bullet” for fatigue.

Instructor References

The materials in this package provide supplemental information on some of the more complex topics covered in the *Understanding Fatigue and Alert Driving* course. Instructors should read these supplements carefully before presenting the associated material, since the teaching points in the instructional package are keyed to the concepts discussed in these references.

Topics included in this package include the following:

<i>Reference #</i>	<i>Title</i>	<i>Topics</i>
1	Fatigue and truck driving	A summary of the fatigue problem trucking operations, with an emphasis on how fatigue is best defined.
2	The role of fatigue in commercial motor vehicle crashes	A summary and description of recent research on truck driver fatigue. This reference includes a discussion of the reasons for the very disparate estimates of the prevalence of fatigue in truck-involved crashes.
3	The physiology of sleep	Understanding how sleep and fatigue interact requires some background in what sleep is and how we investigate it. This reference provides a simple description of sleep architecture and measurement.
4	The physiology of circadian rhythms.	Circadian rhythms interact dramatically with work schedules, sleep loss, and other fatigue contributors, but exactly how and why these rhythms work is distorted by popular misunderstandings. This reference summarizes our present understanding of circadian rhythms.
5	Chemical aids to sleep and wakefulness	Chemical substances (e.g., sleeping pills, stimulants, and other medical interventions) are widely used and misused to prevent fatigue and to counteract its effects. The capabilities and limitations of common drugs are discussed in this reference.

- | | | |
|---|-----------------|--|
| 6 | Sleep disorders | A surprisingly large fraction of the U. S. population suffers from some sort of sleep disorder. The types of common disorders, their nature and impact on trucking operations, and their treatment are the subjects of this reference. |
| 7 | Sleep hygiene | This reference discusses the best strategies for obtaining sufficient quality sleep. |

Instructor Reference 1: Fatigue and Truck Driving

What is fatigue?

Why do we need a definition? The term “fatigue” is used often in everyday language, but most people don’t analyze what they mean when they use the term. Psychologists, on the other hand, have argued and thought about the definition of the term for many years. Why would they do such a thing? First, when scientists use a term in constructing and testing theories they must be absolutely clear about the meaning of the term, and use it uniformly. Second, common usage of the term is imprecise and the word has been used at various times by various people to refer to different things.

- **Fatigue is an internal state.** Some people use the word fatigue to refer to a hypothesized internal state or condition, or to the subjective feeling accompanying this state. Perhaps this is what most of us mean when we say someone is fatigued or tired. We are implying that something has happened inside us as a result of sustained work or exertion or lack of rest, that is experienced as a feeling that we call fatigue. This feeling may be experienced as a loss of the strength, interest, alertness, or motivation needed to continue doing what we have been doing. Such a definition of fatigue proposes an internal state that cannot be directly observed, but is *inferred from observables*.
- **Fatigue is a set of observable changes in behavior.** Since the internal state of fatigue cannot easily be observed or measured, except by asking people to report how they feel, others who are interested in studying fatigue choose to use the term to refer to the *observable effects* of sustained performance or lack of sleep on behavior. These scientists define and measure fatigue in terms of those changes in behavior.

What difference does it make which way we define it? While the two definitions can coexist, we must be clear about which definition we are using when we use the term “fatigue.” If we confuse the two, and lose track of whether we are talking about an internal state or about observable changes in behavior, we easily can be trapped into circular reasoning. We may then conclude that fatigue (the state) is the cause of fatigue (the observables from which the state was inferred). This is hardly a Nobel Prize-winning discovery!

What are the effects of fatigue?

Feeling tired. The first, mentioned above, is feeling tired. Some theorists have suggested that this should be the basis for defining fatigue. A fatigued person, in their opinion, is one who reports feeling tired or fatigued after a period of work or exertion, lack of sleep, etc. If we are concerned about fatigue and work performance, however, we must be cautious

about accepting this as the definition of fatigue. Research has shown that people may report feeling fatigued without showing any deficit in work performance, and conversely may show performance deficits after sustained work or insufficient sleep or rest without reporting feelings of fatigue.

Impaired performance. Fatigue is accompanied by (or, to some, defined by) measurable changes in behavior, many of which degrade work performance. Some of the specific performance deficits are:

- **Decreases in vigilance or attention.** One change that has been associated with fatigue is a loss of vigilance or of ability to maintain attention to the task at hand. This may cause the fatigued worker to miss important cues or events in the environment to which he needs to respond. He or she may fail to notice a cue requiring a response until it is too late to respond correctly. An example of this is a driver who fails to see a stop sign in time to avoid being hit by another vehicle in the intersection. Accident report forms often provide for the code “improper lookout” or “looked but did not see,” recognizing this kind of problem.
- **Response selection and timing.** Slow response time or selection of the incorrect response may also accompany fatigue. For example, the driver may see the stop sign, but apply the brake too late. His timing may be off as he adjusts his speed to round a sharp curve. These behavior changes may be closely related to the attention problems just described, and it is often hard to determine whether an error is the result of impaired attention/perception or a response problem.
- **Impaired judgment.** Some scientists have suggested that fatigue may be associated with changes in judgment or risk-taking. They have done studies showing that for example, a fatigued driver may attempt to pass in a situation where, if he were not fatigued, he would correctly judge that it was risky to pass. More research is needed to confirm that this is a common effect of fatigue.
- **Mood changes.** Emotional and motivational changes can also be seen in fatigued people. A fatigued person is often somewhat impatient or irritable, and may lose his or her motivation to perform job tasks well. Brown (1994) suggests that this loss of motivation is the defining feature of fatigue. The impatience could be a factor in the judgment errors just described, or it could contribute to errors in problem-solving. Irritability can be especially dangerous in teamwork situations, or in the case of a fatigued driver encountering rush hour traffic and reacting emotionally rather than rationally to the situation around him.
- **Sleepiness.** Finally there is the issue of sleepiness. It is easy to treat fatigue and sleepiness or drowsiness as the same thing. Fatigued people are often sleepy or drowsy, and drowsiness obviously impairs performance. It may be considered an extreme example of the attention deficit described above. But sleepiness or drowsiness can result from factors other than fatigue, and it is important to remember

that a fatigued person need not be sleepy to be impaired by fatigue. Four hours of driving in heavy traffic or on icy roads may leave a driver quite fatigued, even if he's had plenty of sleep and has only been on duty for half a shift. On the other hand, a person with a sleep disorder may become drowsy or lapse into "microsleep" episodes after only a short time on duty, without awareness of being fatigued.

What are some common causes of fatigue?

Sustained performance. Sustained work or exertion is the most obvious factor associated with fatigue, and often is cited as one of its causes. Everyone has had the subjective experience of fatigue following a period of physical or mental effort. There are great variations among individuals, and within individuals from time to time, in their tolerance for sustained work and their need for sleep. We refer to these variations when we talk about how much "stamina" a person has, or about his "energy level" or "endurance." Some people can do a great deal of physical labor, but are stressed and fatigued by even a short time at a sedentary task requiring close attention to detail, or by difficult intellectual work. Others have less ability for sustained physical work, but can be mentally sharp at the end of an extended technical problem-solving effort or business meeting that others find exhausting.

Stress. It is impossible to deal with the concept of fatigue without considering its relationship to stress. This becomes complex, because the word stress has all of the same definitional problems as the word fatigue. Generally, stress has been defined in one of two ways. It is either seen (1) as any event, situation, or influence that requires an adaptive response, something that impinges upon a person, or (2) as the individual's response itself. In the latter case, the individual experiences "stress" and the external cause is called a "stressor." What is important here is that fatigue is often experienced as a part of the human stress response and, therefore, any source of stress may also be interpreted as a source of fatigue.

Lack of sleep. Sleep deprivation or disturbance is the most common cause of fatigue. Whether or not they feel sleepy, people who are sleep deprived generally have a lower capacity for work, and experience fatigue sooner than those who are well-rested. The human body requires sleep, and if a person is sufficiently sleep deprived, he may involuntarily fall asleep despite his best efforts to maintain wakefulness. Sleep-deprived subjects in research studies often experience short episodes of sleep (often only a few seconds), called "microsleeps," of which they may be unaware. These can be deadly if they occur while one is driving.

Disturbed schedules. It is not just the number of hours that one has slept that is important here. The sleep-wake cycle and the quality of sleep obtained can affect fatigue. The human body has built-in physiological and behavioral (circadian) rhythms that are synchronized with the environmental day/night cycle. We are evolved to be awake and working in the daytime and to be asleep at night. When these rhythms are disturbed, as by

jet lag, or by working night or irregular hours, fatigue may result.

Many studies have shown that workers who are required to sleep in the daytime and work at night may never completely adjust to the disturbance, and their sleep is not of the same quality as that of people on a more biologically normal schedule. Rotating shifts are especially difficult to adjust to, since the physiological adaptations to a reversed wake-sleep cycle (working at night and sleeping during the day) may take weeks to accomplish.

Clearly, the concept of stress may be relevant here, since disturbances in daily schedule are stressful; they require that we change and adapt in many ways.

A related factor is that even people who are accustomed to working night shifts are likely to perform less effectively during the hours from midnight to 4 AM, when the circadian physiological rhythms of alertness and activity are at their daily lows. A disproportionate number of accidents occur during these hours in industries that work around the clock.

Sleep disorders and illness. Physical disorders such as sleep apnea and narcolepsy, as well as depression, are other sources of sleep disturbance and fatigue or sleepiness during working hours. Some studies have suggested that sleep apnea may be a significant factor among truck drivers, though this remains to be confirmed by further study.

What other factors may influence fatigue?

Work characteristics. Fatigue is not only a function of the amount of time on task and sleep-related variables in an individual. Aspects of the work itself and of the work environment are known to influence fatigue. Perhaps the most obvious of these factors is the interest level and variety of the work tasks. When all else is equal (effort required, time on task, physical environment, etc.) workers become fatigued much more quickly when they are performing boring, repetitive tasks or monitoring systems that require little input from them. The effort of maintaining attention in the face of insufficient stimulation is stressful. Tasks that are varied, that require meaningful responses, and that offer intrinsic satisfaction and feedback (such as from successful problem-solving) are less likely to produce fatigue rapidly. On the other hand, if work is very fast-paced and intense (especially if the worker cannot control the pace of the work), or if the consequences of errors are very serious, it is also likely to be stressful and to result in fatigue.

Thus, the design and content of a job can influence the incidence of fatigue. Most of us think long drives over unchanging terrain, especially at night, can be boring, repetitive, and fatiguing. Effective use of rest breaks can reduce fatigue and increase productivity and alertness, but the benefits of rest breaks are limited.

Work environment. Environmental factors can influence the fatigue associated with a job. As mentioned above, driving in bad weather or poor visibility is much more tiring than clear weather driving. Similarly, it is known that working in the presence of loud noise, heat, high humidity, vibration or other environmental extremes is tiring. Again, the

same factors that make a situation stressful increase fatigue.

Fatigue and commercial vehicle driving

The nature of the work. The job of the commercial vehicle driver typically includes some of the factors known to promote stress and fatigue. It is often monotonous and boring. It may be physically uncomfortable, and may have to be performed when environmental conditions are unfavorable. At the same time, it requires sustained alertness and quick response to changing environmental conditions. Inattention can have catastrophic consequences.

Work schedules, pay schemes, and hours of service. Because of the nature of the trucking industry, many commercial drivers are required, or at least motivated, to work late at night when, all else being equal, they are more subject to fatigue than at other times. They often also work irregular schedules, with consequent disruption of sleep/work cycles. All of these factors promote fatigue. Commercial drivers are often given incentives (for example, pay as a percentage of load revenue) or outright requirements that encourage them to work long hours. Even if they do not exceed the legal hours of service (HOS), they may often work past the point of fatigue to meet a schedule.

Sleep. The environment in which the long-haul truck driver works is not conducive to healthy sleep habits. Sleep is most restful when it occurs at night rather than in the daytime, when it is taken at about the same time every night, and when it is not broken up into short intervals. Commercial drivers often work irregular shifts that make regular sleep impossible, may have to sleep in sleeper berths, during daytime hours, and in split sleep periods. Thus they may not obtain a sufficient quality or quantity of sleep even though hours of service rules are followed.

Symptoms of a fatigued driver

Recognizing fatigue in ourselves. If you notice or feel any of the following, you are probably seriously fatigued, and should at least stop and take a nap.

- Your eyes close or go out of focus
- You have trouble keeping your head up
- You can't stop yawning
- You have wandering, disconnected thoughts

- You don't remember driving the last few miles; you were "on autopilot" (a sign of inability to maintain alertness and attention)
- You have missed your exit or a sign you were looking for (another failure of attention)
- You keep drifting out of your lane, perhaps onto the shoulder
- Your speed has become variable or unstable
- Other vehicles surprise you by their actions (you may have missed early clues to their intentions that you normally pick up when you are fully alert)

Recognizing fatigue in others. If you notice another driver's vehicle doing any of the following, the driver may be fatigued (or otherwise impaired). Most of these are signs that the driver is losing some of his ability to maintain attention to what is going on in his vehicle and the traffic environment and to respond proactively. If you can communicate with that driver, try to convince him to pull over in a safe place and take a break, for his own safety and that of others on the road.

- Changing speed for no apparent reason
- Failing to maintain proper lane position; drifting out of lane
- Failing to respond to traffic situations or signals in an alert, timely way
- Following too closely
- Braking more often than is required by the traffic and road conditions

Instructor Reference 2: The role of fatigue in commercial motor vehicle crashes

This instructor reference summarizes the results of recently conducted key studies on the subject of truck driver fatigue, its prevalence, and its consequences. For each study, the authors' abstract or executive summary is provided, with major findings in **boldface**, followed by notes as needed to clarify the findings or the way in which they may be interpreted.

- Transportation Research and Marketing for AAA Foundation for Traffic Safety. (1985). *A report on the determination and evaluation of the role of fatigue in heavy truck accidents*. Washington, DC: Transportation Research and Marketing.

Executive Summary: The question as to what role fatigue plays in any given accident is a difficult one to answer. Truck driver's logs are often inaccurate and there is a shortage of other material upon which to base any decision on fatigue, short of backtracking the activities of the driver during the pre-accident period. Since backtracking the driver's activity is really the only alternative available in determining the presence of fatigue, it is the method used in this study. A total of 225 accident reports on heavy truck accidents in six Western states were studied. In 221 of these accidents, sufficient data were available to permit at least some backtracking of the driver's pre-accident activities and a determination of the probable role of fatigue in the accident.

In each occurrence, the driver's pre-accident activities were evaluated and a determination made as to whether fatigue was: (1) primary/probable cause; (2) contributory; or (3) non-fatigue related. Specific causes of accidents other than fatigue were defined in two categories: (1) Safety/Mechanical; and (2) DUI. No attempt was made to further define these causes but rather the investigating officer's findings were accepted. In all cases where fatigue was found to be a probable or contributing factor, it is categorized as such. **It is the finding of this study that fatigue is the probable/primary cause of 41% of the heavy truck accidents.** It is also the finding of this study that the number of over-hour drivers could be reduced by supplying enforcement agencies with the proper tools. The most reliable tool possible is the time-stamping and dating of all freight and fuel documents on each trip. A patrolman with a mileage map and a \$10.00 calculator could readily discover hours of service violations in the field if these documents were required to be time-stamped.

Note: Includes cases where fatigue was considered to be a "probable," as well as a primary causal factor. Fatigue was assumed to be present as a cause if the driver had exceeded 15 on-duty hours, or "if non-professional, irrational actions occur at or beyond the 16th hour of continuous activity." Any over-15-hours accident that "could have been avoided had the driver been alert" was judged to have fatigue as a probable/primary cause, along with many where there was not enough information to judge whether the crash could have been avoided. Some of these accidents involved equipment problems.

- Knippling, R. R. & Wang, J. S. (1995). Revised estimates of the U.S. drowsy driver crash problem size based on general estimates system case reviews. *39th Annual Proceedings*, Association for the Advancement of Automotive Medicine, Chicago, IL.

Abstract: A revised estimate of the incidence of crashes involving driver drowsiness/fatigue is provided based on analysis of General Estimates System (GES) data and a review of 562 GES cases from 1993. Cases selected for review had coded characteristics suggesting a “Drift-Out-Of-Lane” scenario but were *not* cited as drowsiness-related in GES. The case review identified some “definite,” “probable,” and “possible” drowsy driver crashes not captured by the normal GES data coding process. **It indicated that drowsiness/fatigue is a discernible causal factor in 1.2 to 1.6% of Police Accident Reports, as compared to the baseline GES estimate of 0.9%.**

Note: This is a re-analysis of police accident reports (PARs) suggesting that fatigue is somewhat underreported in PARs. This study looks at all vehicles, not just trucks, and concentrates on determining the proportion of “drift-out-of-lane” crashes that may be fatigue-related.

- Knippling, R. R. & Wang, J. S. (1994). *Crashes and fatalities related to driver drowsiness/fatigue*. (Research Note) Washington, DC: National Highway Traffic Safety Administration.

Abstract: This report summarizes recent national statistics on the incidence and characteristics of crashes involving driver fatigue, drowsiness, or “asleep at the wheel.” For the purposes of this report, these terms are considered synonymous. Principal data sources are the NHTSA General Estimates System (GES) and the Fatal Accident Reporting System (FARS), although these data files are acknowledged to have limitations for quantifying this type of crash causal factor. Most data provided are for the five-year period 1989-93. Findings from other studies of the incidence of drowsiness/fatigue in crashes are reviewed. Finally, overviews are provided of NHTSA programs underway to help provide better data to assess this traffic safety problem and, more importantly, to develop effective countermeasures.

Note: Reviews recent research on drowsy-driver crashes; **mentions estimates from 1% to 4% of all crashes, and concludes that 1% is probably too low, but it is difficult to quantify the problem using currently available information.** Does not provide definitive estimate of proportion of crashes caused by fatigue. Notes that “the overall national drowsy driver crash problem in terms of absolute number of crashes (and related injuries and fatalities) is primarily a passenger vehicle problem, and that trucks have a relatively low rate of involvement per vehicle mile traveled. Nevertheless, when viewed from an *individual vehicle* perspective, the drowsy-driver crash risk (both crash likelihood and probability of a fatality) is considerably greater for combination-unit trucks.”

- National Transportation Safety Board. (1990). *Safety study: fatigue, alcohol, other drugs, and medical factors in fatal-to-the-driver heavy truck crashes (Volume 1)*. (Report No. NTSB/SS-90/01) Washington, DC: National Transportation Safety Board.

Abstract: This report is an analysis of human factors involvement in fatal-to-the-driver,

heavy truck accidents in eight States over a 1-year period, October 1, 1987 through September 30, 1988. Data presented are derived from in-depth investigation of 182 accidents which involved 186 heavy trucks and resulted in 207 fatalities. The accident investigations were conducted in California, Colorado, Georgia, Maryland, New Jersey, North Carolina, Tennessee, and Wisconsin. These accidents represent approximately 25 percent of this type of accident nationwide. Volume 1 (NTSB/SS-90/01) of the study includes an analysis of fatigue, alcohol, and other drug prevalence and medical factors in these accidents, presents findings, and makes recommendations to improve heavy truck safety. Volume 2 (NTSB/SS-90/02) contains the 182 case summaries that provided the data discussed in Volume 1.

Note: **This study found that 31% of the sample of crashes investigated (fatal-to-the-driver heavy truck crashes) had fatigue as a “probable cause or factor.”** Findings can be generalized only to fatal-to-the-driver crashes, which are **not** representative of all heavy truck crashes. Fatal-to-the-driver crashes are disproportionately single-vehicle crashes, crashes occurring at night, and run-off-the-road crashes. These crash types are known to be associated with fatigue.

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- National Transportation Safety Board. (1995). *Factors that affect fatigue in heavy truck accidents. Volume 1: Analysis; Volume 2: Case summaries.*

Executive summary: The Safety Board analysis of Fatal Accident Reporting System (FARS) data indicates that in 1993 there were 3,311 heavy trucks involved in 3,169 fatal accidents, in which 3,783 persons died (432 were occupants of the heavy trucks). Research has suggested that truckdriver fatigue may be a contributing factor in as many as 30 to 40 percent of all heavy truck accidents. In 1990, the Safety Board completed a study of 182 heavy truck accidents that were fatal to the truckdriver. [See above.] These 182 accidents were a census of the heavy truck accidents that were fatal to the driver in the eight participating States. The primary purpose in investigating fatal-to-the-driver heavy truck accidents was to assess the role of alcohol and other drugs in these accidents. The study found, however, that the most frequently cited probable cause was fatigue. **The Board believes that the 31-percent incidence of fatigue in fatal-to-the-truckdriver accidents found in the 1990 study represents a valid estimate of the portion of fatal-to-the-driver heavy truck accidents that are fatigue-related.**

Because of the significant number of heavy truck-related fatalities and the significant role of fatigue in such accidents, the Board initiated this study of single-vehicle heavy truck accidents to examine the role of specific factors, such as drivers' patterns of duty and sleep, in fatigue-related heavy truck accidents and to determine potential remedial actions.

The purpose of the Board's study was to examine the factors that affect driver fatigue and not to study the statistical incidence of fatigue. Therefore, the Board specifically selected truck accidents that were likely to include fatigue-related accidents; that is, single-vehicle accidents that tend to occur at night. The Board desired to obtain approximately an equal number of fatigue-related and nonfatigue-related

accidents through its notification process.

The Board was specifically interested in obtaining accurate information regarding the truckdrivers' duty and sleep patterns for the 96 hours preceding the accident; therefore the Board limited the accidents to those in which the driver survived and was available to be interviewed by the Board's investigators to reconstruct the previous 96 hours.

The Safety Board investigated 113 single-vehicle heavy truck accidents in which the driver survived. However, because the 96-hour duty/sleep history that was required for the study was not available for 6 drivers, the 6 accidents in which these drivers were involved were not included in the study. The study, therefore, analyzes data from 107 single-vehicle heavy truck accidents.

Based on the determination of probable cause, 58 percent of the accidents (62 of 107) were fatigue-related. The remaining 42 percent of the accidents (45 of 107) were not fatigue-related. Nineteen of the 107 drivers stated that they fell asleep while driving.

The Board emphasizes that the conclusions reached in this study are not based on a set of anecdotal accidents, although the merits of such Board studies have proven valuable in the past. Rather the results are based on a multivariate statistical analysis (a multiple discriminant analysis) that was performed to simultaneously evaluate the relationship of a set of measures of the drivers' duty and sleep times to the groupings of accidents established by the investigators' determination of probable cause (fatigue-related and nonfatigue-related accidents). The statistically significant analysis determined that the most important measures in predicting a fatigue-related accident in this sample are the duration of the last sleep period, the total hours of sleep obtained during the 24 hours preceding the accident, and split sleep patterns.

Based on the results of the analysis, the safety issues discussed in this study are:

- the factors that affect fatigue-related accidents
- the adequacy of the Federal Highway Administration's hours-of-service regulations, and
- the adequacy of truckdrivers' understanding of the factors that affect fatigue.

As a result of this study, recommendations were issued to the Federal Highway Administration, the Professional Truck Driver Institute of America, the American Trucking Associations, Inc., the Commercial Vehicle Safety Alliance, the National Private Truck Council, the Independent Truck Owner operators, the Owner-Operator Independent Drivers Association, the International Brotherhood of Teamsters, and the National Industrial Transportation League. The recommendations focus on the Federal hours-of-service regulations and truckdriver education.

Note: This study selected crashes for study that were likely to be fatigue-related. **The 58% of those selected crashes that the study found to be fatigue-related should not be taken as representative of the general population of heavy truck crashes, nor even of single vehicle heavy truck crashes.** Unfortunately, the 58% figure has been misinterpreted and generalized by some media and advocacy groups, and you need to be aware of this.

Instructor Reference 3: The Physiology of Sleep

Understanding sleep and how it affects fatigue and trucking operations requires some knowledge of biological functions and how they are measured. Sleep is complex and, even after decades of research, a somewhat mysterious state, and much of our understanding comes from scientific studies. Sometimes these studies inform us that what we thought we knew about sleep is wrong. To teach effectively about the interaction of sleep and fatigue requires more depth than we would guess, and this discussion is designed to prepare instructors to answer questions and to provide background for in-class discussions.

Sleep architecture

A typical night's sleep consists of cyclic sleep stages. These stages are not readily distinguishable when we watch a sleeping person; in fact, we differentiate these stages by the type of electrical activity in the brain. While it is unnecessary to discuss these processes at length in class, it is helpful to understand the nature of these stages and the way they are measured.

In studying sleep in the laboratory, we can take a variety of measures. The first is EEG (*electroencephalography*), which is the measure of changes in electrical potentials on the surface of the brain. These changes in voltage really represent the collective “chatter” of millions of nerve connections. The measurement is usually done using small electrodes attached to the scalp, plus an amplifier (the potentials are very small, measured in thousandths of a volt or millivolts, abbreviated mV). The frequency and amplitudes (rate of change and amount of change) can be studied by researchers directly, or analyzed by computer to extract information about brain activity. We can also use a measure called EOG (*electrooculography*), which monitors electrical impulses to the muscles that move the eyes and EMG (*electromyography*), which measures muscular activity, usually of the neck muscles.

Four stages of sleep can be identified by brain activity (Figure 1).

- **Stage 1** occurs just as we drift off to sleep; brain activity is dominated by low-amplitude, high-frequency waves similar to those measured while the person is awake and alert.
- Stage 1 shifts into **stage 2** with the appearance of bursts of rhythmic waves in the frequency range 10-16 Hz (Hz = *Hertz*, or cycles per second), called *alpha waves*. In stage 2 we also see the appearance of **K-complexes**: short periods of high-amplitude slow waves followed by a short burst of waves in the alpha (14 Hz) range.

- In **stage 3**, high-amplitude, low-frequency *delta waves* begin to appear.
- By **stage 4**, the deepest sleep, these delta waves predominate.

There are behavioral aspects to these stages as well: it is more difficult to awaken someone from deep sleep, and in such a state the person awakened is temporarily less responsive to surroundings or to stimulation.

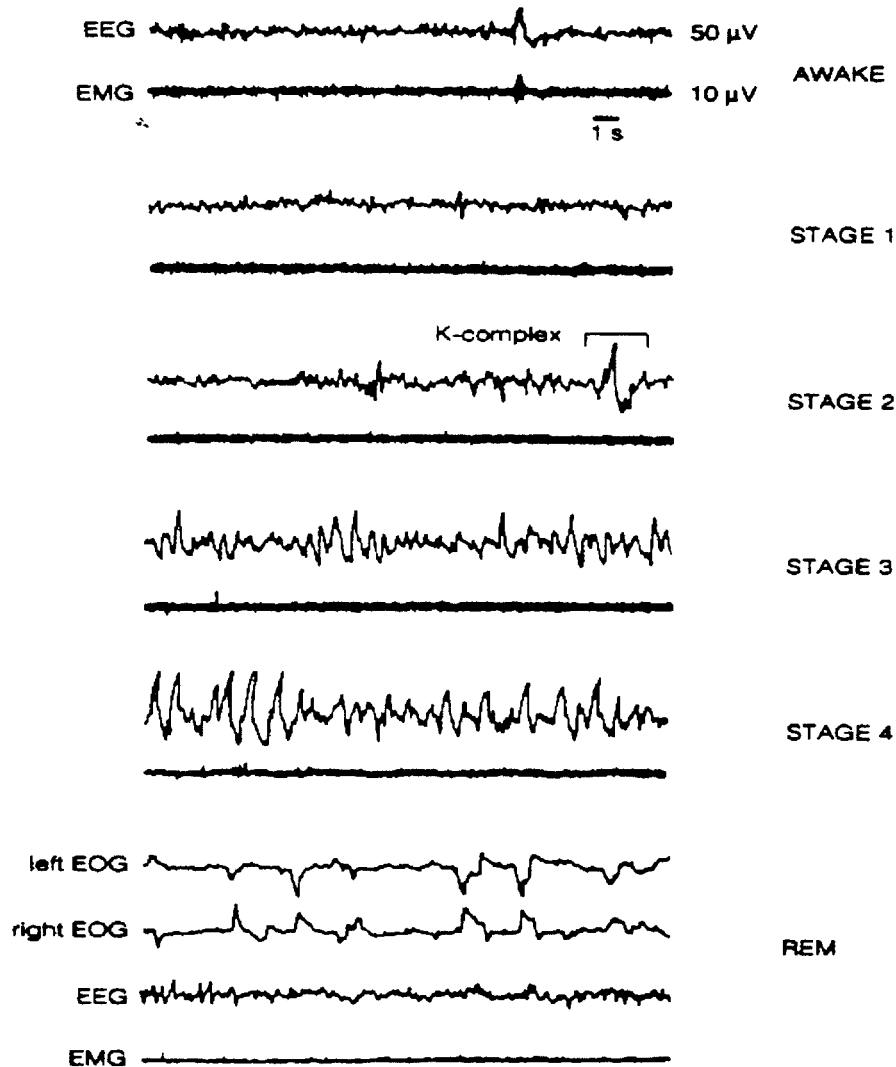


Figure 1: Sleep and brain activity. These examples of EEG, EOG, and EMG records show the systematic change from rapid, irregular brain activity in a wakeful state to high-amplitude slow-wave activity at deeper levels. In REM sleep, note the very active

eye movements (EOG), the “flat” state of other muscles (EMG), and the similarity of REM and AWAKE EEG states.

REM and NREM sleep

Most people have heard of REM or *rapid eye movement* sleep, but their understanding is usually limited to a notion that “REM is when we dream and our eyes move,” which is somewhat uninformative and not quite true. Most of our sleep is NREM, or non-REM, but simply characterizing this kind of sleep as “the kind where our eyes don’t move” also falls short of a useful notion.

REM sleep is sometimes called “paradoxical sleep,” because it is like sleep and isn’t at the same time. A person in REM sleep *looks* asleep, but the brain activity is much like that of a person who is awake. The acronym REM refers to the fact that the eyes are moving rapidly under the closed lids. REM sleep is also associated with dreaming, but the popular belief that REM sleep is the only time we dream is false; we dream in other stages, though apparently less frequently. The dream pattern and content in REM are more likely to be the sorts of bizarre narratives we remember. In other stages, dream content is more likely to be vague and similar to thoughts and musings about daily experience and other real-life topics.

REM is also accompanied by a phenomenon called **REM-sleep atonia**. Atonia means “without tone” and refers to muscle tone, which is a state of partial muscle contraction. In REM sleep the muscles that we use to move our limbs are relaxed; in effect, we are paralyzed while REM is going on. The reason appears to be that we might act out our dreams and suffer injury if our ability to move were not temporarily inhibited.

What is important for our purposes to understand is that we *need* all these states and stages to get a good night’s sleep. The sleeper moves through the stages (beginning with an initial stage 1 period as we fall asleep, then generally cycling through stages 2-4, with occasional periods of REM. Figure 2 shows a period of about 5 hours, beginning with the point at which the person being monitored falls asleep. The sleeper first enters stage 1, then quickly moves into deeper sleep. After a time, the cycle moves up again into lighter sleep (stages 2-3), and at the peak of each cycle there is typically a period of REM sleep. The total cycle is generally about 90 minutes in duration, and is repeated throughout the night’s sleep.

REM sleep is apparently a necessary sleep component; experimental subjects who are awakened each time REM sleep starts suffer from anxiety, irritability, and impaired concentration (Dement, 1960). In addition, after a period of deprivation, the periods of REM increase, as if the brain is attempting to make up a deficit.

Why is REM important? This is not fully understood, but two possibilities seem to be supported by current evidence. The first is the *consolidation hypothesis*, which suggests that the brain is transferring information learned during the day into long-term memory storage, much like a computer file server “backing up” the day’s files. The second concerns *protein synthesis* (see “The Physiology of Circadian Rhythms”). Proteins are synthesized at a greater rate in the brain when activity is high, and particularly when new nerve cell connections are being formed (as is apparently the case when newly learned material is being permanently encoded). Protein synthesis is highest during REM sleep. In addition, newborn infants, whose brains are going through rapid growth in number of such interconnections, related to rapid learning, get about eight hours of REM per day!

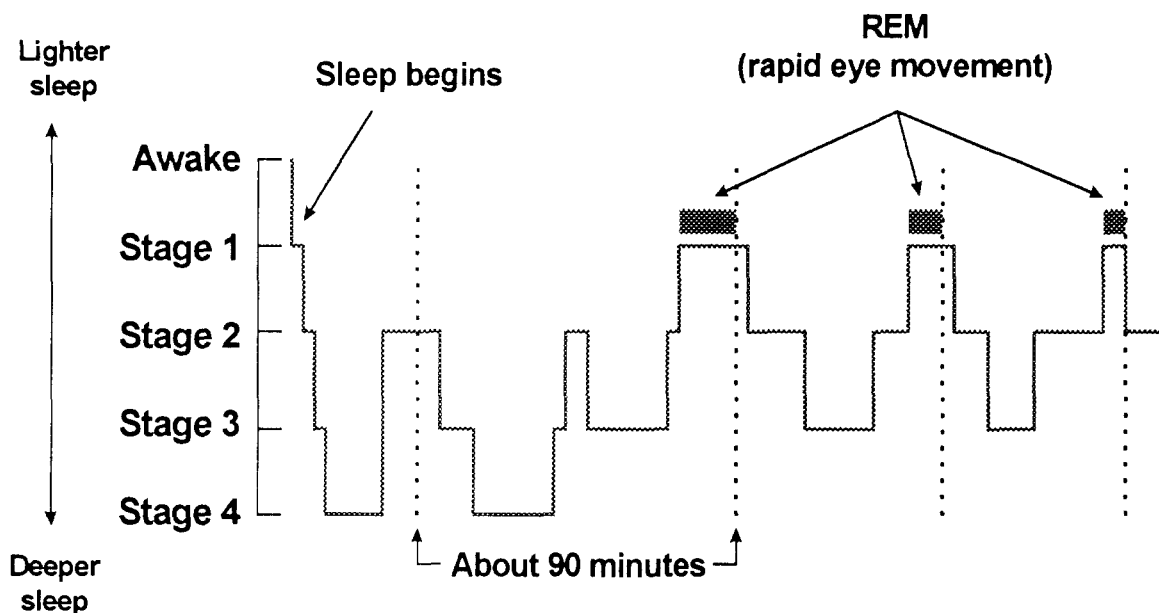


Figure 2: Sleep cycles. This chart shows about 5 hours of typical sleep (red or dark line). Rightward movement of the line shows the passage of time, while vertical movement shows changes from one stage to another from lightest sleep (stage 1) down through deepest sleep (stage 4), punctuated by periods of REM sleep (shaded blocks).

“Quality sleep”

What is particularly important about this discussion of sleep architecture is that *quantity* of sleep is not the only factor that contributes to whether or not we are tired or fatigued. While most people are technically well-rested with 7-8 hours of sleep per night, and can frequently make do with less for limited periods, the *quality* of the sleep is vital. Eight one-hour naps do not equal eight hours of continuous sleep. Why? Because each of the sleep stages, as well as the REM and NREM “mix” perform vital functions. A one-hour nap, for example, does not usually permit the completion of a full sleep cycle. If our short-term sleep history leaves us short of these *types* of sleep, the effect may be that we

feel as if we had not slept at all. In addition, “recovery” sleep, when we make up for lost sleep, has more time set aside for deeper sleep (unless, as noted above, the sleeper has been REM deprived).

Under what circumstances would we experience broken, intermittent, disrupted sleep patterns? One good example is in a job that has frequent schedule changes, a job in which during busy periods we might miss normal sleep and simply snatch a nap or a rest break whenever we could.

Sound familiar?

Instructor Reference 4: The Physiology of Circadian Rhythms

Biological rhythms

The body is governed by a variety of biological rhythms. Some, like heart beat, hormone secretion, digestion, and respiration, have very short cycles. Others (like hibernation cycles in some animals) are much longer. One cycle that affects sleep and that can influence the effects of fatigue and performance is the *circadian rhythm*. The term “circadian” comes from Latin *circa* (about) + *die* (day), hence “about a day.” It is so called because the cycle is just about 24 hours in length, and is normally in synchrony with the course of a day.

Sometimes this cycle is represented in graphs (for example, line charts of body temperature) as being *sinusoidal* — that is, having a gentle, uniform, snakelike shape. Actually, the cycle is more complex than that. Figure 1 shows slightly less than three complete circadian cycles (that is, three days) using body temperature, which fluctuates regularly with the circadian rhythm. Temperature (1) rises fairly steadily during the day, (2) tapers off in the mid-afternoon, and (3) drops at night. The changes are more complex and critical to performance than simple body temperature, however, and an understanding of the nature of the cycle is vital if you are going to teach others about its origins and effects.

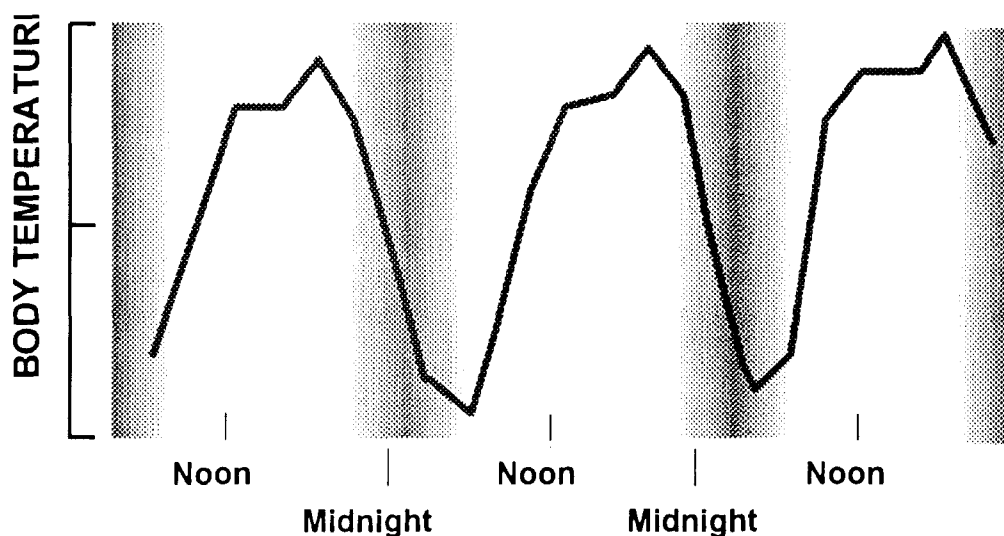


Figure 3: Three days of circadian rhythms, measured by body temperature. Temperature is lowest through the night into the predawn hours (1-4 AM), with a secondary leveling-off in mid-afternoon (2-5 PM).

The circadian clock

If the actual cycle is really only *about* a day, why don't we get out of synchrony with day and night, like a slow watch? The reason is that we have evolved a system to reset the clock. There are several outside sources of information, but the most important appears to be light. Remember that we evolved before electricity; night was dark and day was light. Sunrise was (and is) the most obvious sign that the day has begun, and this event is the principal signal for resetting the circadian clock. Mechanisms that set the circadian rhythm are called *Zeitgebers* ("TSITE-gaybers" — German for "time givers").

Light enters the eye and is changed (*transduced*) into the electrochemical energy of the nervous system at the retina. The signals caused by the light travel from each eye down the separate pathways of the optic nerve. The optic nerve pathways cross at the *optic chiasm* (*chiasm* is from a Greek work meaning "cross"). Some nerve fibers continue to the same side of the brain as the eye where they began; others cross over to the other side of the brain. But a few fibers depart from the optic nerve at this point and travel a very short distance to the *suprachiasmatic nucleus* (SCN). The SCN is part of a collection of organs called the *hypothalamus* which controls a number of internal body functions.

The SCN responds to the information from the eyes about light levels in the environment with neural signals to the pineal, which responds by secreting the hormone *melatonin*, which travels widely through the body.

The hormone **melatonin** is believed to be the principal agent for synchronizing body processes that control the circadian rhythm. But melatonin doesn't appear automatically when darkness falls. The SCN actually has an internal clock-setting function that triggers melatonin release at the proper time (if, of course, the external *Zeitgebers* are correct). The process of synchronizing all relevant body functions to follow the circadian rhythm is called *entrainment*.

Circadian effects in the body

What happens to the body as it swings through the circadian cycle, and why does it matter?

The 24-hour cycle is marked by dramatic changes in levels of body function. The principal "down" time is late at night and early in the morning (before dawn). During this time, body temperature is low, hormonal activity is focused on restorative and growth functions, and we generally want to be asleep. The body is trying to conserve energy during these periods, and tends to resist our attempts to violate this evolved master plan.

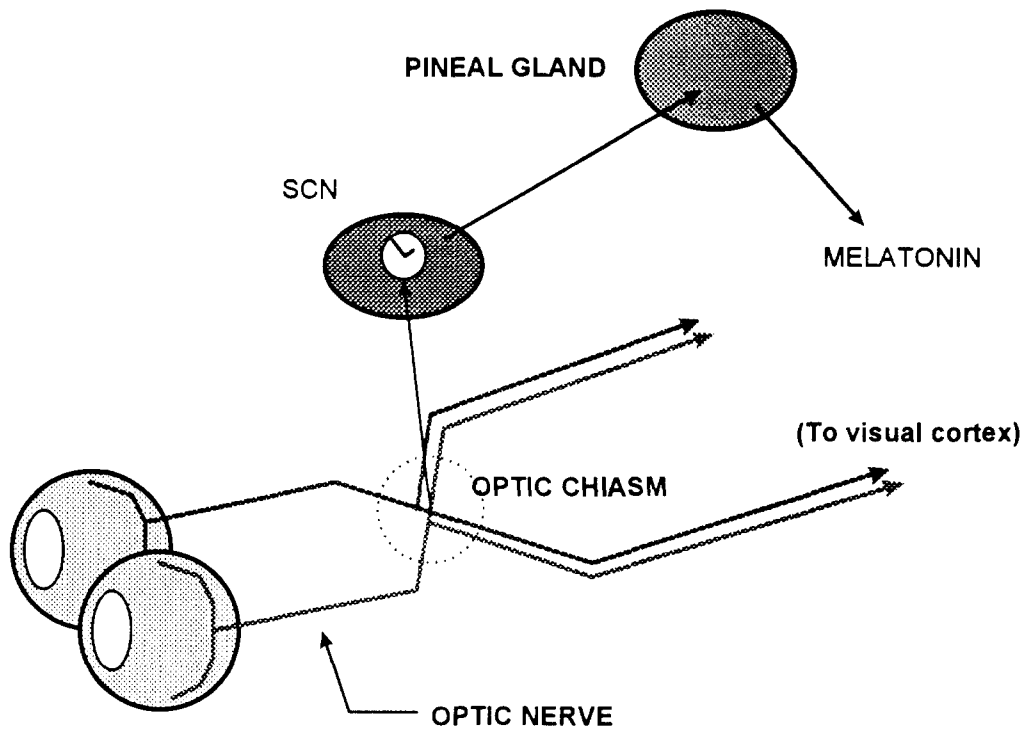


Figure 4: Mechanisms of the circadian rhythm.

The easiest variable to measure is body temperature, but there are other changes. The neurotransmitter *Dopamine*, which is produced in the brain and is involved in a variety of

functions (including programming body movements) declines during sleep, possibly in part because there is less physical activity. Chemicals in the nervous system called *catecholamines* (Dopamine is one) generally decline during the circadian lows, as do physical responses such as grip strength and optical reaction time (Krieger & Hughes, 1980). Corticosterone production also declines on a circadian schedule, but this appears to be independent of the circadian rhythms affected by the SCN; instead of melatonin, the controlling hormone appears to be ACTH (*adrenocorticotrophic hormone* from the pituitary gland). There are also changes in digestive activity that fluctuate with the circadian cycle.

The point is, the body would far prefer to be asleep during the circadian lulls, conserving energy, restoring levels of vital substances, and staying out of trouble. Unfortunately, the world economy evolves faster than the body. This mismatch between the requirements of business and our readiness for sleep is what makes the circadian rhythm a vital factor in highway safety.

There are obvious effects of circadian lulls, which occur twice daily — a general drop in the mid-afternoon called the *postprandial dip* (literally “after lunch,” though it is not necessary to eat a meal to experience the effects) and particularly in the very early morning (about 1-4 AM). The effects we notice include:

- **Decreased response rates and a lowering of mental performance.** The quickness of our responses declines, our judgment is affected, we are simply not as alert as we are when the brain thinks we *should* be alert. The circadian rhythm is stubborn, and shifting it for night work in particular is no easy task.

For example, because our reaction times are slower, we may not see an obstacle ahead on a dark highway as quickly when we are in a circadian low. During such periods, our vigilance is typically somewhat reduced even if we are awake and trying to be attentive, and our working field of view — the central field of vision within which we can detect subtle events — is narrower. We all know this feeling. What we are doing is fighting the body's instinct to stop fooling around with busywork and do things like rebuilding hormone levels and consolidating the day's memories.

- **Decline in mood and motivation.** Mood and motivation are low during circadian lulls, and the effect is most pronounced in the 1-4 AM period. For example, we may be capable of performing at the desired level, but fail to do so because the energizing effect of motivation is reduced.
- **Increased sleepiness and reports of fatigue.** If we are awake during circadian lows, we are more likely to be sleepy and more likely to be uncomfortably aware of it. The word “uncomfortably” is critical. Sleepiness is a signal that the body should be asleep; the circadian cycle and all the processes that fluctuate in synchrony with it are combining to make you do just that.

Instructor Reference No 5: Chemical aids to sleep and wakefulness

Introduction

Instructors for this fatigue course should make it very clear that use of most, but not all classes of **stimulant drugs** as countermeasures to driver fatigue is not recommended; and for most applications would be in violation of prudent safety practices and highway safety regulations. At the present time, there is good potential for use of only a select few stimulant compounds (e.g. particularly caffeine). Perhaps current medical research will lead to additional alternatives in the near future.

Likewise, many sleeping pills and other sleep aids are readily available and have been in use for years. There are numerous acceptable uses for some of these sleep aid compounds; and there are situations where they probably are used inappropriately. This primer is meant to provide background information on stimulants and sleep aids, and to describe pertinent research findings to permit instructors to engage in class discussions on these topics as they pertain to truck driver fatigue.

Drugs affect sleep and fatigue

Many chemical substances (drugs) affect quantity and quality of sleep, our wakeful alertness, our mental and physical performance, and our subjective sense of sleepiness. Such chemical substances may be prescribed medications, over-the-counter remedies available in most pharmacies, recreational drugs, and/or illegally obtained drugs from our country and abroad. The large annual medical suppliers' volume entitled "The Physician's Desk Reference" lists *drowsiness* as a side effect of over 550 prescription drugs and over-the-counter medications; it lists *fatigue* as a side effect of over 250 drugs, and lists *insomnia* for almost 500 drugs.

To find ways to get more useful sleep, medical studies have evaluated sleeping pills, anesthetics used in relaxing medical patients before surgery, and other hypnotic drugs used for sedation. Many studies examined stimulant drug effects on our abilities to remain alert, attentive, and performing well even after considerable sleep deprivation. Much of this performance oriented research has been carried out by military medical research laboratories in the past 10 years (for review see the special issue journal of *Military Psychology* by Babkoff & Krueger, 1992).

Drug effects on humans prompt consideration of many important variables, including the type of drug, its pharmacokinetic properties, the dose and frequency with which one takes the drug, age, gender, the psychological state of the user (e.g. whether in a state of depression), whether administration of the drug is acute (taken once) or chronic (e.g. a repeated treatment regimen intended to supply the body/brain with a maintenance level of the drug). With repeated use, "tolerance" or "adaptation" to use of any drug may occur to

the point that the effects are no longer obtainable as they were when you first started taking the drug, or to a point that increased doses are needed to obtain the same effects.

Pharmacokinetic properties of drugs vary when taken at different times of the day (circadian rhythms), as do the effects a drug exerts on body physiology.

"Chronopharmacology," the study of the timing of drug effects, explains why physicians prescribe medications be taken at particular times of day, as in "before meals," or "before bedtime" or "every four hours" etc. These drug specific factors are important for fatigue countermeasure applications (Buysse, 1991).

Effects of stimulants on alertness or wakefulness

This review is limited to coverage of only those classes of stimulants pertinent to truck driver fatigue issues, and includes those related to amphetamines, and to caffeine.

The stimulants of interest generally decrease subjective fatigue and sleepiness in healthy adults, particularly during long and tedious tasks, or during sleep deprivation. For example, amphetamines can improve performance on tasks requiring physical endurance, quick reaction times, certain types of task monitoring, and simple cognitive tasks such as mental arithmetic. There is less evidence that amphetamines boost performance on tasks requiring complex cognition (thinking and reasoning) or decision-making. The performance enhancement effects of these stimulants are most often noted under conditions where the recipient of the drug is fatigued or sleep deprived.

Amphetamine, Methylphenidate, and Pemoline: Stimulants like amphetamine and other related compounds are sometimes prescribed for medical and therapeutic purposes, as in treating attention deficit disorder in children, obesity, clinical depression, and narcolepsy. Obviously our society's "drug user culture" uses such stimulants as recreational drugs as well; and almost everyone is familiar with issues of legality of use, chances for substance abuse, and the likelihood of addiction associated with this class of stimulants.

After oral administration, each of these three stimulant drugs is rapidly absorbed into the blood stream, readily distributed throughout the body, and easily crosses the blood-brain barrier. Within two hours, these drugs usually reach their peak blood levels, and the plasma half-lives are short, ranging from 2 to 12 hours. Pemoline is somewhat longer acting than amphetamine or methylphenidate.

Single moderate doses (about 10 mg) of amphetamine, methamphetamine, and methylphenidate tend to make us think that sleep duration was shorter than it actually was, and they adversely affect the structural make-up of our sleep stages. Higher doses (60-100 mg) of pemoline are required to produce similar effects. Some studies demonstrate noticeable effects of these three stimulants on REM and NREM sleep at rather low doses, and with a slightly higher dose they cause sleep continuity disturbances (e.g. 5 mg and 10 mg for methylphenidate respectively). The most **predictable effects** of each of these chemical agents are that they keep us awake longer, that is, it takes more time to fall

asleep, the total amount of sleep decreases, sleep efficiency becomes degraded, body movements (more tossing and turning) are increased, the latency before REM is longer, and the amount of REM obtained decreases (Buysse, 1991).

When we take amphetamine or methylphenidate repeatedly (e.g. several times per week), and then cease taking it, "**rebound sleep effects**" often occur. That is, as the body withdraws from these drugs, we feel very sleepy; our sleep periods become very long, our REM and slow wave sleep are both more variable, implying less restfulness, and we tend to become more irritable and may even have some depression.

Performance effects of amphetamines. Amphetamines clearly can counteract loss of attentiveness in fatigued individuals and they can improve performance on physical endurance, simple reaction time, and monitoring tasks, as well as simple cognitive tasks, such as easy arithmetic, verbal recognition etc. It is not clear whether they enhance learning or not, or if they improve performance on complex intellectual tasks.

Because of the potential to sustain and enhance performance with stimulant compounds, several military forces around the world are performing controlled medical research to explore their effects on performance and to determine implications for health and operational effectiveness. These medical research laboratories are not advocating general usage of such stimulants, but rather, are attempting to do good medical research to acquire data to advise military units who already use such compounds (albeit in limited ways, but alas, without medical guidance); and these labs are trying to develop suitable stimulants for operational application in the future (see Babkoff and Krueger, 1991).

Amphetamines are out of the question for use by truckers as a fatigue countermeasure.

The major problem with suggesting operational use of any of these stimulant drugs, even in specialized military situations, is that each drug presents significant drawbacks. That is:

- a) these drugs should not be used operationally except under the watchful supervision of qualified medical personnel (preferably a physician);
- b) most of them are either prescription drugs, or their use for other than strict medical treatment is illegal;
- c) there is a general concern for unpredictable physiological and psychological effects; and
- d) they permit opportunities for addiction and other drug abuse.

For these reasons and other more practical considerations, this class of drugs is, for now, *out of the question* for use by truckers as a fatigue countermeasure.

Caffeine as a stimulant for alertness

Caffeine, of the class of drugs called methylxanthines, is the most widely used stimulant. Caffeine produces widespread physiological effects on the body (raises heart rate, blood pressure etc.) and clearly has important stimulating effects on the central nervous system.

(CNS). The focus of discussion here is whether or not we can use caffeine as a fatigue countermeasure to keep us awake and alert while driving.

Caffeine is readily found in coffee, tea, chocolate, many soft drinks, select foods, and as an over-the-counter stimulant under several well-known brand names (e.g. No-Doz), as well as an ingredient in other medications (e.g. diet pills etc.).

Caffeine is one of those chemical substances to which many people develop a physiological adaptation or a tolerance for its stimulating effects. This may be attributable to the fact that many of us consume so much of it. Many people repeatedly drink as many as 6-10 cups of caffeine-laden coffee per day. If we regularly consume substantial amounts of caffeine, our bodies adapt to it. We will build up a tolerance that nullifies its effects, and we will subsequently require a higher dosage to obtain the same stimulating effect when it is desired.

Thus, we should not take in caffeine regularly if we plan to use caffeine as a stimulant to awaken us, or to maintain a certain level of alertness during a long duty shift. Rather, we should strive to preserve its impact for those times when we would like caffeine to give us a jolt.

There typically is enough caffeine in one 4-ounce cup of coffee (from 100-300 mg) to lead to subjective sensations of its stimulating effects. Since coffee is mostly hot water, we may actually sense a "rush" from the first sip, but this may as much be from the coffee taste and the hot liquid as it is from the caffeine content. The stimulating effects of caffeine normally become fairly noticeable about 20-30 minutes after drinking the coffee. Thus, we should drink our caffeinated coffee about a half-hour before we desire the stimulating effect.

In general, caffeine in moderate amounts, (depending on our level of adaptation) increases our subjective impressions of alertness (we feel sharper) and decreases our subjective sleepiness (we feel perky). Coffee drinkers commonly verbalize claims that it gives them new energy, wakes them up, stimulates them, makes them more efficient, keeps them awake etc. For those people who regularly consume large amounts of caffeine, these subjective effects may progress to include anxiety, irritability, tremors, and insomnia.

As for caffeine effects on performance, most such research indicates caffeine's stimulating effects are somewhat less than taking amphetamines. (That is probably good.) Although there are considerable differences in research studies which assessed caffeine effects in different ways (e.g. many studies did not use a sleep deprivation paradigm), generally the findings indicate that caffeine slightly improves physical endurance, vigilance and monitoring performance. It has less effect on reaction time except in very sleep-deprived subjects, and is not as impactful on higher level cognitive tasks. In some studies caffeine actually impaired short term word-recall, and motor performance requiring steadiness. Another set of studies pointed out that caffeine effects on performance may interact with time-of-day effects and even personality traits such as introversion/extroversion.

Caffeine Effects on Sleep. If we consume four cups of coffee over about a two hour period, (400-1200 mg of caffeine), most of us will experience troubles falling asleep; we will have less restful sleep (more tossing and turning); the normal sequence and amount of sleep stages will be disrupted; and we will sleep a shorter duration. Heavy caffeine users report less sleep disruption than light coffee drinkers. Clearly those kinds of effects can adversely impact the quantity and quality of sleep we obtain. If we are planning to sleep, care must be taken to insure that we do not consume caffeine for several hours before laying down to sleep.

Research on New Stimulants

Several military medical research laboratories, in Europe and the United States, continue the search for safe, effective stimulant substances and compounds for sustaining and/or enhancing operator performance in the operational environment. However, these research programs do not advance quickly. Any promising new medical developments will eventually find their way into the civilian medical community and into our societal norms and expectations as well.

In 1996, two promising stimulating compounds are being examined with some enthusiasm for their fatigue countermeasure potential in the operational environment. These include: a) application studies for safe use regimens for moderately high levels of caffeine, and b) research with a new French drug called *Modafinil*, a stimulant compound which successfully kept operational people alert during sustained operations in the 1991 Persian Gulf War.

Concluding remarks on stimulants

Thus, for the present, use of **amphetamine**-like stimulants should be forbidden in the trucking industry. Suitable use scenarios for **caffeine** to provide short term stimulation during select portions of some driver's work-rest-sleep schedules *can be encouraged*, but it is important for drivers to be better informed about the best conditions for caffeine use as part of their individual fatigue countermeasure planning. There is some hope on the horizon that future medical research will identify novel stimulants which are suitable for use in the operational trucking environment, but the time is likely to be after the year 2000. (See Babkoff & Krueger, 1992; Buysse, 1991).

Sleep Aids

The most common methods of artificial induction of sleep include the use of hypnotic drugs such as a) the class of sleeping pills called benzodiazepines, b) the use of remedies containing antihistamines, and c) consuming alcohol.

Hypnotics, (Sleeping Pills): Benzodiazepines are among the most widely prescribed sleep-inducing medications available. Generally, these drugs are accompanied by fewer adverse side-effects and have less potential for lethal overdose than the barbiturates which were more popular in the 1960s. When properly prescribed, benzodiazepines are safe, effective medications for many applications. However, most of these compounds each have their own set of drawbacks too. They are sedating drugs which the body develops a tolerance to with repeated use. There are chances for addiction to them, and with higher doses; and there are likely to be performance impairments the next day after a drug-induced sleep.

Single doses of short-acting or long-acting benzodiazepines before bedtime prompt subjective reports of shorter sleep latencies (go to sleep quicker), decreased awakenings during the sleep, and increased depth of restful sleep. Objective EEG measures corroborate those subjective statements. Benzodiazepines consistently reduce the amount of Stage 1 and increase the amount of Stage 2 sleep. Slow wave (stage 3-4) sleep is more variably affected. Most studies show significant decreases in SWS, but others show no change or slight increases, and most studies find little or no change in the amount of REM sleep.

One important effect of benzodiazepines is that they tend to *increase the number of sleep apnea events*, which would be a particular concern to many apneic truck drivers

Benzodiazepines are designed to induce and maintain nighttime sleep. If administered in the daytime, they increase sleepiness dramatically as expected, and in most cases, the person who took the drug may feel sleepy enough to just want to go to bed, and sleep would readily come. More to the point, the concern for drivers is *whether one is sleepy the day following a drug-induced night's sleep*. In moderate doses, benzodiazepines often produce complaints of "hangover" and sleepiness the following morning. This effect is dose-dependent, and is more pronounced with the longer-acting drugs than the shorter-acting benzodiazepines.

U.S. Army research with .25 mg of triazolam (Halcion) found good sleep inducing effects without subjective reports of hangover, and importantly, no real significant performance detriments on different types of taskings during the day after awakening from drug induced sleep periods. British military studies have shown similar, but slightly less impressive results with temezepam. There seems to be enough good research to state that under conditions of proper medical guidance (perhaps a company physician trained in these matters) these two short-acting benzodiazepines offer some promise for inducing sleep without introducing substantial hangover effects the next day.

Currently, use of benzodiazepines or other such compounds is only achievable through prescription by a physician. It is not likely that will change soon. *Thus, for now the operational use of such sleeping pills is probably not likely without a physician's supervision.*

Antihistamines: Many prescription medications and over-the-counter remedies for allergies, head cold, and sleeping pills contain antihistamines. Antihistamines are quickly absorbed from the gastrointestinal tract, have an onset of action in 15-30 minutes, reach peak levels in 1 to 2 hours, and the effects last from 3 to 6 hours.

When taken in the usual doses prescribed for relief from allergies or head cold symptoms, some of the most commonly used forms of antihistamines (e.g. diphenhydramine and its derivatives) cause subjective sleepiness. They have often been prescribed as a mild sedative to assist in going to sleep, and some of them work pretty well for that purpose.

Most antihistamines have also been shown to produce moderate degradations in performance. Circadian variation in subjective sleepiness effects have also been reported. Usually, a person seeking allergy relief takes medication containing antihistamine repeatedly to develop a maintenance level of the drug in the body. As most instructions on the pill bottles indicate, these drugs should not be mixed with consumption of alcohol, the user should not attempt to drive or operate heavy equipment while under their influence. This can be a problem for the truck driver who has allergies.

The pharmaceutical industry continues to develop non-sedating alternative antihistamines. A few newer antihistamines claim to provide effective allergy relief, with the desirable feature that their chemical actions do not cross the blood-brain barrier, and thus should not induce sleepiness as do the more traditional Dramamine-like antihistamines. Preliminary U.S. military medical research indicates two new brand-name antihistamines (Seldane and Hismanal) may be suitable alternatives to the Dramamine variety, and may indeed have little or no adverse sleepiness effect on performance. These new antihistamines may pave the way to approval for operational use. The research continues; and many allergy sufferers anxiously and hopefully await the outcome. If these medical tests prove the efficacy and safety of these new classes of antihistamines, *they would have good application in the truck driving community.*

Melatonin. A hormone secreted by the pineal gland (a pea-size structure in the center of the brain) during darkness is believed to play a role in making us sleepy. Synthesized into tablet forms, melatonin is one of the latest natural supplement "miracle" compounds sold in health food and grocery stores in the U.S.A. So many advertising claims have been made about many positive benefits of taking melatonin it makes one wonder why we aren't all taking melatonin on a regular basis.

The advertising overstatements claim that melatonin may bolster our immune systems, keep our cells from disintegrating from free radical damage, slow the growth of cancerous tumors and cataracts, ward off heart disease, extend life, and in high doses prevent

pregnancy. But the benefits which perk our interest here concern claims that melatonin also acts like a natural sleeping pill, can be used to help us sleep better, to ease insomnia, assist in resetting our circadian clocks during work shift changes, and help to combat jet lag.

Melatonin is readily available in pill form, and is inexpensive (a month's supply costs \$10-\$15). Because melatonin, a synthesized hormone, is claimed to be a health food supplement, and not a drug, the U.S. Food and Drug Administration (FDA) has made no statements about its goodness or badness. The FDA just states that melatonin is not a regulated compound, that no FDA sponsored testing has occurred, and users are warned that they take it "without any assurance it is safe or will have any beneficial effect."

So how does it apply to truck driver fatigue? The 1995-96 advertising and popular press blitz of melatonin claims makes truck drivers and their families as curious about melatonin as anyone else who attends to the news. Undoubtedly many truck drivers now use melatonin regularly. If for no other reason than to acknowledge it, discussion in the fatigue outreach program is warranted. Additionally, early medical research, some of it in military medical laboratories, illustrates that this sleep aid compound may become an important contributor to our repertoire of fatigue countermeasures.

What we think we know about Melatonin. We are pretty sure about certain features of melatonin, and briefly these include:

- Humans produce melatonin in fairly high levels at a young age (nighttime levels are highest in children 1-3 years of age); but, before puberty the pineal gland releases less melatonin; thereafter, our melatonin production drops overall, as the blood levels of melatonin decline steadily into old age. Middle-aged adults secrete only half as much melatonin as children; by age 70 melatonin levels are very low. Researchers hypothesize this may be one reason why elderly people do not sleep as well; like so many other interesting questions about melatonin, that research has yet to be done.
- As the sun sets and darkness begins, the pineal gland produces a surge of melatonin that goes to all parts of the body. When sunlight hits the retina, neural impulses signal the pineal gland to slow melatonin production, and that which is already in the body quickly dissipates. Experiments showed bright lights can trigger the response to cease our melatonin production; but research findings are less clear about our body's ability to initiate production of melatonin simply by going into a darkened environment during daytime.
- Melatonin seems to assist us to feel drowsy and to fall asleep more quickly. Research now shows as little as 1/10th of a milligram (mg) of melatonin can hasten the onset of sleep, whatever the time of day. Sleep researchers generally induce sleep in their lab studies with doses of from 0.1 to 0.3 mg. *People who take melatonin as a sleep aid report sound sleep at night, and no resultant grogginess the next day.*

Through its actions on other hormones, melatonin helps keep our daily biological rhythms in synchrony with each other (at least many of our circadian rhythms) and with the seasons of the year. Therefore much research is being conducted to determine the mechanism by which melatonin can be used to help us reset our biological clocks. Practical applications include being able to time our use of melatonin and sleep to adjust to work-shift changes (shift lag) and as we travel across time zones (jet lag). A 5 mg dose of melatonin per day worked successfully with aviation employees in adjusting to new time zones. Even a low dose can be used to "trick" the body into thinking that dusk (darkness) has arrived earlier, especially if you then enter a darkened room and try to sleep.

Researchers studying melatonin looked for classical problems normally associated with traditional sleeping pills (suppression of REM sleep, losing the hypnotic impact over time with repeated use, chance for addiction). So far no substantial concerns have been demonstrated on these topics, but such research continues.

Medical researchers found no immediate dangers of overdosing by taking too high a dose of melatonin (one study gave 6 grams, that's 6,000 mg, to human volunteers every night for a month with only resultant stomach discomfort and residual sleepiness). This encouraging finding contrasts with risks of overdose with almost any other sleeping pill.

U.S. military medical researchers recently completed several operational studies examining effects of small doses of melatonin used as a sleep inducer in conjunction with flights across time zones. The initial results indicate longer sleep periods were obtained (as much as 1-2 hrs longer per night) and there was no noticeable degradation in subsequent performance on cognitive and psychomotor tasks. These laboratories continue such research.

Concerns about Melatonin: Not enough good medical research has been accomplished with melatonin. A number of questions and concerns therefore remain, including:

- What dosage and use regimen is safe for melatonin for specific purposes? Currently most sleep research is done with doses of 0.1 and 0.3 milligrams of melatonin. Something less than one milligram dose is probably recommended for most operational applications. However, most readily available melatonin pills are prepared in substantially higher doses than the levels of melatonin normally secreted into our body by the pineal gland. Many health food stores sell synthetic melatonin tablets in 1 to 5 mg tablets (a 10 times higher dose than is required to induce sleep). This prompts heightened concern about the advisability of treating our bodies to this overdose of a hormone so intimately linked to many of our important biological processes.
- What are the unknown long-term health consequences? Almost nothing is known about the long-term effects of taking melatonin supplements.
- What are the implications for use by adolescents? The body's natural production of melatonin seems higher in children during their growth phases. Children's growth hormone production levels change dramatically around puberty, and their interactions

with melatonin are unknown. Skeptical medical researchers, worrying that our teenagers and young adults might repeatedly take high dose melatonin supplements, caution that medical science may some day determine an adverse relationship between high doses of melatonin supplements and adolescent growth patterns and sexual maturation, and may produce detrimental effects to the health of young adults. This is a caution worth heeding. We ought to warn teenagers and young adults accordingly. Our society has had its share of over-enthusiasm for miracle solutions in the past (remember the thalidomide babies born in the 1950s?). Our youth have few memories of such disastrous adverse consequences of unproved drugs.

- Is it safe to take melatonin with other drugs?
- Is it safe to take melatonin while pregnant?
- How can we be sure the manufacturers of synthetic melatonin use pure ingredients and sound production methods? Since it has not been subjected to the FDA approval process, for now consumers are forced to trust what is on the label, and there are lots of low quality manufacturers in the non-regulated health food industry. Thus far there has been no reason to assume melatonin is any more hazardous than other unregulated health food supplements.
- It is important to take melatonin at the correct hour, and therefore users must be cautioned against taking melatonin without proper consideration of the timing of the onset of drowsiness and a strong urge to sleep. It would not do well to have the onset of sleepiness at the wrong time of the day, resulting in a sleepy driver on the road.

Alcohol: is the most widely-used psychoactive drug in the world. Ethyl alcohol (ethanol), a simple organic molecule, is the active ingredient in any alcohol beverage (beer, wine, whiskey, gin, etc.). Ethanol is rapidly absorbed throughout the intestinal tract, quickly gets widely distributed throughout the body, and just as quickly crosses the blood-brain barrier in high concentration. Consequently, the subjective effects on sleep, sleepiness and performance are readily seen. Alcohol, like other sedatives, clearly impairs performance. The focus here is what impact alcohol has on our sleep and our state of alertness or sleepiness.

Effects of Alcohol on Sleep and Sleepiness. In moderate amounts, alcohol reduces sleep latency (the time it takes to fall asleep) and in low doses, even helps us to extend our sleep duration, or continuity. However, in higher doses, alcohol disturbs our sleep structure (stages) and often results in subjectively disturbed sleep.

The effects of **alcohol** on our **sleep** are dose-related. Within limits, consumption of 3-4 ounces or more of alcohol before retiring to bed leads to obvious shorter sleep latencies (fall asleep quicker) and to pronounced decreases in REM sleep, increases in slow wave sleep (SWS), and in some cases, tossing, turning and intermittent wakefulness. The effects of alcohol on REM sleep and SWS are biphasic: in the first half of the night, REM

is decreased and SWS increased; and in the second half of the night, REM increases and SWS decreases. Even in healthy individuals, single doses of about 1 ounce of alcohol lead to variable reductions in sleep latency, produce intermittent awakenings, and exhibit inconsistent effects on total sleep time. Additionally, having consumed alcohol the previous night affects sleep the next day, usually resulting in shorter sleep continuity and less quality sleep.

Consumption of even moderate amounts of alcohol (1-3 ounces) leads to a dose-related increase in the level and duration of **subjective drowsiness** even in healthy young subjects. Some studies quantifying effects of a single low-moderate dose of alcohol, demonstrated that it reduces our subjective sense of alertness, and increases feelings of fatigue; furthermore, *when the alcohol is combined with moderate sleep deprivation, the alcohol intensifies the sleep deprivation effects on subjective alertness*, making us noticeably less alert. However, these effects have repeatedly failed to show the adverse effects of alcohol on our alertness to be as severe as those we experience when we miss only a single night of sleep.

Since the trucking community has considerable concern for **sleep apneics**, it is worth noting that a single large alcoholic drink prior to bedtime can significantly increase the number and severity of oxygen desaturation episodes and increase the number of apneas in asymptomatic men. Thus *consuming alcohol before sleeping can adversely impact apneic episodes* and thereby worsen daytime sleepiness the next day.

The effects of alcohol on our state of mental alertness and our sense of fatigue are not arguable. Instructors should **discourage the use of alcohol as a sleep inducer** because *even moderate amounts adversely affect our sleep quality*. Secondly, use of alcohol has marked effects on performance of the awake driver, and the effects can linger up to about 10 hours after drinking, even after a lengthy sleep after drinking (e.g. next day hangover). Because there is so much social and law enforcement attention to our use of alcohol and driving, **the issues are well known**. The standard cautions employed in the aviation industry might prevail here as well. We should abstain from consumption of alcoholic beverages about 12 hours before driving a truck on the highway.

Instructor Reference 6: Sleep disorders

There are any number of disorders that can affect the quality of sleep. Some have been known for thousands of years, some have only been recently identified, and few are fully understood. In many cases, those who suffer from the disorders are not even aware that they do, only that they feel tired. Researchers have estimated that from 8 to 15 percent of American adults have chronic sleep problems (Weitzman, 1981). Truck drivers are as likely as any segment of the population to have these problems (and in some ways more likely), but because of the job demands and the consequences of poor sleep on highway safety, detecting and diagnosing sleep disorders is particularly important for truckers.

Insomnia

“Insomnia” simply means “a state of sleeplessness,” but technically refers to a common set of conditions that prevent or disrupt sleep. There are really three basic kinds of insomnia: *onset insomnia*, *maintenance insomnia*, and *termination insomnia*.

- People suffering from **onset insomnia** have difficulty getting to sleep, and may lie awake for a long time.
- **Maintenance insomnia** is associated with frequent awakening during what should be a period of solid sleep.
- **Termination insomnia** occurs when a person wakes up too early and cannot get back to sleep.

Insomnia is not, in itself, a disease. All adults suffer from insomnia from time to time (called *acute* insomnia). Common causes are stress, disruption of the circadian cycle (as in jet lag or shift lag), or just trying to go to sleep at the wrong time in the circadian cycle. It may also be caused by drugs and medications, trying to sleep in an unfamiliar place (some of us often have trouble going to sleep in motel rooms), an awkward sleep posture, consuming caffeine before going to bed, a noisy environment, or an uncomfortable room temperature. We have all experienced onset insomnia, for example, when we go to bed worried or unusually excited.

Insomnia becomes a problem when it is *chronic* — that is, when it happens frequently and over a long period of time. There are reports of people who have not slept in years, but these are rare and difficult to authenticate. For most of us, insomnia is a sometime thing, but when the “sometime” is associated with a period when we must remain alert and awake or we pose a safety hazard, insomnia is a serious matter.

Insomnia can be treated with drugs that aid sleep. Nonprescription over-the-counter (OTC) drugs generally include some form of *antihistamines*, which induce drowsiness, usually for a period of six to eight hours. While these can be useful and are generally safe,

unsafe situations can occur if the use of OTC drugs is not carefully planned or if the work schedule is very uncertain — for example, if you take antihistamines for a quick nap two or three hours before starting a trip, the drowsiness will still be there when you start to drive.

Prescription sleeping pills are usually from the Benzodiazepine family — drugs like Diazepam, Librium, Valium, Triazolam (Halcion), and Temezepam. These are much safer than the barbiturates used in the 1950's (which were unsafe enough in overdose to be the suicide drug of choice), but there are drawbacks even to modern sleeping pills.

Use of sleeping pills may help you obtain sleep at night, but there is a possibility that drowsiness will linger after you wake up — in effect, a sleeping pill-induced hangover. Different people metabolize the drugs at different rates, and they are prescription drugs specifically because of this: the dosage must be appropriate for the user. Like all chemical interventions in the body, we tend to become *adapted* to their use — that is, the body adjusts to their presence (and, from the body's point of view, their disruption of natural processes) and after a time, larger and larger doses will be required to create the same effect. This may, paradoxically, disrupt sleep, an effect called **drug-dependency insomnia**. Finally, after prolonged use there may be aftereffects of the drug (sleepiness, difficulty getting to sleep) that can cause problems.

Sleep apnea

The National Sleep Foundation estimates that up to 20 million Americans may suffer from sleep apnea. Until the early 1970's, many cases of apparent insomnia went unexplained. The discovery that some people simply have episodes during sleep in which breathing ceases until the sufferer awakens, gasping for air, explained many of these cases (Dement, 1974). This disorder is called **sleep apnea** (literally “without breath”). Besides being a source of poor quality sleep, it is potentially life-threatening.

The immediate cause appears to be an abnormal relaxation of the throat muscles; in some cases there appears to be a shutoff of the brain signals that keep us breathing. There are three kinds of sleep apnea:

- Apnea caused by simple muscle relaxation is called **obstructive apnea** because the soft tissues at the back of the throat (uvula and soft palate) relax enough to sag and literally close the airway.
- **Central apnea** occurs when there is an interruption of the rhythmic contractions of the diaphragm and the chest muscles.
- **Mixed apnea** involves a combination of obstructive and central apneas, usually observed as a brief episode of central apnea followed by longer, repetitive periods of obstructive apnea.

These conditions are commonest in middle-aged men and in people who are chronically overweight, and are often found in people who snore.

Sleep apnea *can and should be treated*, particularly if your job requires alertness (as with truck drivers). Sleep apnea can also contribute to heart and lung disease. Obstructive apnea can be treated using a device to maintain continuous positive airway pressure (CPAP), an air compressor that literally forces air down the trachea. Tongue retaining devices, similar to those used by dentists, can be used with some effect in less severe cases, as well as drugs and surgery to correct airway abnormalities.

How do you know if you have sleep apnea? Excessive snoring may be a sign (unless you sleep alone, you will have been informed of this condition!), as well as unaccountable tiredness during the day, degradation of concentration and memory, and morning headaches.

Restless legs syndrome (RLS)

RLS is a descriptive term for a discomfort of the lower limbs that causes us to move our legs, disturbing sleep. The cause is unknown, but it may have a hereditary component. Unlike sleep apnea, it is neither medically serious nor life-threatening. On the other hand, it is extremely bothersome to someone who suffers from it, and can cause insomnia; in severe cases, the resulting insomnia can lead to clinical depression and other secondary effects.

Since its cause is unknown, treatment tends to emphasize “what works.” Massaging the legs, getting up and walking about, hot showers, hot wraps, and similar strategies may provide some relief and factors such as environmental stress, fatigue, and caffeine use may make RLS symptoms worse. Some medications have proved helpful, among them the Benzodiazepine family of sleep aids and L-DOPA. DOPA (dihydroxyphenylalanine) is a chemical produced by the brain that is involved in, among other things, brain programming of muscle movements. It is often used as a treatment for Parkinson’s disease, and seems to have some effect on the discomfort of RLS as well.

RLS is commoner among older people, and seems to be worse during such periods of hormonal fluctuation as pregnancy and menopause. The National Sleep Foundation stresses that it is *not* a functional psychological disorder, but a medical disorder.

Delayed (or advanced) sleep phase syndrome

These are causes of insomnia related to jet lag or shift lag, and develop because our sleep patterns are out of phase with our circadian rhythm. What distinguishes these conditions from actual jet lag is that no travel is necessary; the circadian cycle simply goes its own way without help from the airlines.

The principal culprit appears to be an out-of-phase circadian temperature cycle (Czeisler et al., 1980). If the temperature cycle is delayed (that is, the downward shift is later than the usual bedtime) or advanced (our body temperature goes down before bedtime), we may try to go to sleep when the body is unprepared. If the phase is delayed, onset insomnia (difficulty in getting to sleep) may occur; if advanced, termination insomnia (awakening earlier and being unable to get back to sleep) may result.

The common corrective action for this problem is to alter the sufferer's sleep times systematically (usually by an offset of 3 hours per day) until sleep schedules and circadian cycle are back in phase, as we do to combat jet lag (*Chronotherapy*; Czeisler et al., 1981). This is difficult to accomplish unless the person suffering the sleep phase syndrome has enough flexibility to schedule the sleep times, but since this is the single best solution such a regimen may be necessary.

Narcolepsy

Narcolepsy (from Greek, and meaning “a seizure of numbness”) is the most intrusive of the sleep disorders, since it can occur at any time with dramatic effects. People who suffer from narcolepsy fall asleep at inappropriate times, though usually associated with sudden emotional arousal — even something as innocuous as laughter. These “sleep attacks” typically last only a short time (from a few seconds to 30 minutes), but even a few seconds of sudden and unexpected loss of wakefulness can have serious effects for drivers.

Narcolepsy appears to be a sudden entry into a condition similar to REM sleep, caused by some failure of the areas of the central nervous system that regulate sleep. It may begin gradually as episodes of daytime sleepiness. This is a serious affliction for several reasons. Attacks may occur in the middle of conversations and cause embarrassment; like REM, sleep attacks may include dreamlike episodes called *hypnagogic hallucinations*; and atonia (a relaxation or absence of muscle tone) of the neck muscles or other muscle groups similar to REM sleep atonia may occur as well. Narcolepsy may also disturb night time sleep.

Upon waking, narcoleptic persons can suffer *sleep paralysis*, in which the muscular atonia of REM does not disappear and the waker is unable to move for a few minutes.

Cataplexy sometimes accompanies narcolepsy. In these attacks, usually triggered by a strong emotion such as anger or surprise, the brain simply shuts off muscle tone and creates a state similar to REM sleep atonia in a person who was quite conscious a moment before. This is worrisome, but aside from injuries arising from an accidental fall, not particularly dangerous. However, if the person is driving when such an attack occurs, this can mean loss of control of the vehicle for seconds or minutes, with devastating results.

Like apnea, narcolepsy can be treated. The commonest approaches address lifestyle: regular sleep schedules, good diet, avoidance of overstimulating situations. Narcolepsy

can also be treated with drugs such as amphetamines, but these have dangers and side effects that may be worse than the condition they are treating. On the good side, people with narcolepsy are usually aware that they have the disorder, and can — if they are willing to structure their lives wisely — avoid the most dangerous effects.

Do you have a sleep disorder?

As with all medical problems, self-diagnosis of sleep disorders is tricky, but it is possible to assess the probability that you suffer from any of the conditions described here (except narcolepsy, which is hard for you or those around you to miss). Common signs of sleep disorders include:

- Excessive daytime sleepiness
- Falling asleep at inappropriate times
- Taking a long time to fall asleep at night
- Waking up feeling tired
- Muscle soreness and stiffness upon awakening
- Excessive snoring or gasping (you will have to ask someone else about this one!)
- Kicking or thrashing while asleep
- Sleepwalking (somnambulism)

Instructor Reference 7: Sleep Hygiene

Practicing good sleep hygiene is much like any other modern health and wellness philosophy. We should understand and recognize our need for obtaining sufficient **quantity** and **quality** of sleep in order to feel refreshed, to be maximally alert, to perform our best, and to preserve our health and well being. The concepts are similar to those concerning medical guidance to follow a good nutritious diet, a physical fitness program, and to practice good preventive medicine. A *sleep hygiene plan*, including a personal sleep discipline program, can be likened to practicing good **preventive maintenance for our brains and our bodies**. A desirable outcome of this fatigue outreach program might be to convince truck drivers they would benefit immensely from writing their own short sleep hygiene or discipline plan, and then encourage them to follow their plan.

Obtaining Quantity and Quality of Sleep.

Most adults function best at everything they do when they obtain daily, uninterrupted, restful sleep, a duration of 7 to 8 hours or longer. A good night's sleep can be restorative, recuperative, and refreshing; it will brighten our attitude, enhance our motivation, maintain or enhance our abilities to perform well, help to preserve our health, and most importantly: provide for maximum driving alertness.

Quantity of Sleep. Thus the idea is to strive to obtain at least 7 to 8 hours of sleep per 24-hour day and to get as much of that sleep as we can in one continuous sleep period. That way we maximize our chances for obtaining not only the *quantity* of sleep we require, but the *quality* of sleep we need as well.

Most of us have practical experience with partial sleep loss, and we live and function in our daily lives with less than 7 to 8 hours of sleep in our 24-hour day. We probably think we are "alert enough" and consistently perform fairly well with as few as the 5, 6 or 7 hours of sleep we ordinarily average. However, even with allowance for individual differences, ample research indicates most of us with that repeated shortage of sleep do not actually perform our best in many of our activities; if we had our performance assessed, those measures would indicate that although we operate acceptably well to get by, we would likely operate better if we were well rested. Subjectively, those of us who are chronically slightly sleep deprived also report more sleepiness and fatigue than those who are well rested. Thus, **obtaining at least 7 to 8 hours of restful sleep per night should be given a high priority.**

There is room for argument about *how we accumulate* that sleep in any 24-hr day. That is, we might question whether or not we can package that sleep in two 4-hr periods, or four 2-hour periods, or a combination of 6 hrs with 2 hrs etc., or does it matter? In many ways, it does matter how we acquire that desired quantity of about 8 hours of sleep per 24-hr day. As the reference material on the physiology of sleep points out, having eight 1-

hour sleep periods may provide the equivalent *quantity* to the 8-hour night of sleep, but because of the way our brain structures our sleep in stages, it is highly unlikely to provide equivalent sleep *quality* in terms of recuperative value and restoration of mental alertness.

Almost any combination of 8 hours of sleep is generally preferred over getting less sleep and thereby avoiding a **sleep debt** (see earlier materials on this). Secondly, the next most important thing is to recognize the benefits of the **continuity of sleep** principle to maximize the length of uninterrupted sleep periods.

Continuity and Quality of Sleep: As the material on the physiology of sleep pointed out, through the night our sleep generally sequences through four stages of NREM sleep, and we spend considerable time in REM (dream) sleep as well. Our sleep cycles last about 90 minutes each. Most of the time, such cycles permit us to obtain at least one, and sometimes two periods of REM sleep during each 90-minute cycle. The remaining sleep time in that cycle will be filled with varying amounts of NREM sleep in accordance with what the brain decides we need.

The *continuity of sleep principle* suggests that the longer we can sleep, continuously, without interruptions, awakenings, disturbances etc., the more restful, recuperative, and restorative of alertness that sleep period is likely to be. This is because a long, undisturbed sleep permits us to cycle through the sleep stages in the order and the duration our brain requires. This postulates that our brain will follow the preferred sleep sequence to obtain the amount of sleep in each of the sleep stages that would serve us best at that particular time. That is, the brain is ecologically selective in picking up the sleep we need most.

On a regular basis we should obtain **as long a continuous sleep period as we can** (preferably 7-8 hours every night). If we cannot obtain 7-8 hours of continuous sleep, then it is recommended we obtain as long a continuous bout of sleep as conditions permit, whether it be 4, 5, 6 hours or more. Most sleep proponents argue we should strive to obtain **at least 4 hours continuous sleep** at a time, because that amount allows us an opportunity to obtain at least two sequences (cycles) of REM sleep, believed to be necessary for restoration of alertness. This will permit our brain to do its thing: select the sleep stages we need most. We should supplement that 4-hrs of sleep with a daytime nap or two to accumulate the desired 7-8 hours of sleep.

In summary, to be well rested, we should strive for the longest continuous, uninterrupted sleep period we can obtain; and when it is necessary to sleep shorter times, adhere to the idea of striving to **get at least four continuous hours of sleep at a stretch**. (See naps).

Naps

When we speak about *naps* we usually think of obtaining a short period of sleep to *augment*, or *supplement* the usual long sleep obtained the night before, or to *replace sleep missed* because our night was shortened. Perhaps because we didn't obtain enough sleep and we feel a bit sleepy, a short period of additional sleep would help us feel more alert; and so we take a *nap*.

Naps can be of **any duration**, but usually a short nap is a half-hour or more, and a long nap lasts as much as 2 hours or longer. Naps can be *pre-planned*, as in: "I am going to sleep these specific five hours tonight, and then on my long drive, I plan to stop off at a nice truck stop I am familiar with, crawl into my sleeper berth, and take a 2-hour nap beginning about 1:30 p.m. tomorrow." Or, naps can be more *spontaneous*, as in: "Right now, I feel quite tired, and can't make it through this long drive. I guess I'd better find a safe place to pull over and take a 45-minute nap before proceeding."

Napping Principles. In terms of sleep hygiene, our strategy should include being aware of and applying the following napping principles:

1. Following the continuity of sleep principle, the **longer we can sleep** in one sleep session **the better** in terms of obtaining quantity, and quality sleep. Generally, longer naps are preferred to short ones.
2. As for **timing of our naps** we should remember that in accordance with our circadian rhythms, our bodies would **prefer to sleep during the circadian lows**: that is, it will be easier to take a nap any time from midnight till 5:30 a.m., and again in early to mid-afternoon from about 1:00 till 5:00 p.m. Note, these times also are the best times during which to obtain our long sleep (7-8 hrs) of the day - because physiologically, it is when the body is most ready to sleep.
3. After any nap, no matter what the duration, drivers should be mindful of the need to **shake off sleep inertia effects** before resuming a drive. Depending upon our particular state of sleepiness, and how big a sleep debt we have accumulated, when we take a nap, we may quickly fall into the deeper stages (3-4) of sleep, and upon awakening, find it difficult to snap ourselves into a state of alertness to drive safely. Although sleep inertia can occur after awakening from a nap of almost any length, it is most common after naps of longer than 45 minutes, because often it takes that long to fall into deep sleep. Ways to awaken out of sleep inertia include doing moderate exercise, (e.g. walking, jumping up and down etc.) particularly outdoors, by drinking caffeine-laden coffee (which can take 30 minutes to produce the jolt), or engaging in an attention demanding conversation with someone until our alertness returns.
4. Obtaining sleep from several supplemental short naps, e.g. 45 minutes now, and 45 minutes later, two more hours still later, when added to our a shortened long-sleep (e.g. 4-5 hours duration), can help us accumulate our required 7-8 hrs sleep per 24-hr day. Although this is not the most efficient way to obtain sufficient recuperative or restorative sleep, this napping tactic is usually better for us than obtaining no

supplemental sleep. However, if we attempt to sustain ourselves on five or six 1-hour naps over a period of days, we will probably encounter large amounts of sleepiness and loss of alertness. Soon thereafter we would have to get a long restorative sleep of about 7 or more hours.

5. Availing oneself of ultra-short naps (10-20 minutes) can provide a real boost, a quick refresher. These short naps can help a driver to press on a little longer until he/she can get to a place where he can devote the time to obtain more quality sleep. Such naps are only recommended for "quick fix" situations, when a driver might feel quite drowsy, and just can't seem to stay awake at the wheel. In that instance, a truck driver could pull over in a safe place and sleep in the cab for about 15-20 minutes, or preferably longer, but generally for less than 45 minutes. That driver must remember **to deal with sleep inertia upon awakening from any nap.**

Using multiple ultra-short naps (e.g. five or six of the 15-minute naps over a night's drive) may occasionally get a driver through a single night's drive successfully. But repeatedly attempting this procedure, night after night, promises to put him/her into an acute shortage of restful sleep to the point that the driver is likely to perform poorly in the same way he/she might if he had stayed up all night, and missed an entire night's sleep.

6. In terms of on the road operational strategies, drivers who work regular routes usually know the locations of good, safe rest stops where they can obtain sleep. If they don't know, they certainly should consult other drivers, and or road maps that mark such truck stops. **Drivers should pre-plan their route and identify their planned rest and sleep stops; and then they should follow that plan** to ensure they are the safest, most alert drivers they can be on the road.

Sleep Discipline Planning

The best advice regarding sleep is to tell drivers to "**plan their sleep schedules ahead of time**" and to make concerted efforts to adhere to the plan to ensure they obtain a sufficient **quantity** and **quality** of sleep before and during every road trip. Drivers should think out and prepare a simple **written sleep hygiene or sleep discipline plan** for themselves, and then discuss this plan with families, loved ones, team driving partners, perhaps even dispatchers if that might help with scheduling.

A good **driver sleep discipline plan should include:** identification of whether one is a morning or evening person, what the working schedule requires, and permits in terms of timing for the work shift, the alternatives for off-duty time for rest and sleep, consideration of family and social situational variables and needs. It should also identify what fatigue countermeasures are to be employed (that is developing good sleep habits at home and on the road; and following the operational strategies for long haul driving).

There are many things that truck drivers can do to ensure they obtain a sufficient quantity of good quality sleep at home, as well as while on the road on long haul trips. Although not meant to be all encompassing here, some of these measures include things such as: buying and using soft ear plugs and a sleep mask; darkening the sleeping room or sleeper berth; using a fan for background masking sounds; unplugging the telephone and disabling the door bell to prevent interruptions in daytime sleeping; being careful about what one eats, and when one eats, being mindful of the sleep schedule, etc. These sleep strategies and fatigue countermeasures, and others not mentioned here, should be written into the sleep plan. Such a list will serve as a reminder to drivers when they review their plan several weeks after writing it, and find they have undoubtedly neglected to follow through on such promises to themselves.

Getting quality sleep at home

For drivers who work hours other than normal daytime work hours, those who work evening or night shifts or varying hours, and those who are away from home a lot (like long-haul drivers), it can be difficult to balance home and work demands on their time and still make time for good sleep habits. Here are some things that people with experience working such hours, and other business travelers, have found helpful to reduce the stress and conflict associated with such working conditions.

- Negotiate with your family and close friends to set priorities for how your time at home will be used; be open with each other about your needs and wants, and realistic about the demands of your job (and theirs). If you have children, include them in these discussions, to the extent they are able to participate. Once you discuss these issues openly, and each of you recognizes that you'll have to compromise a bit, it will be easier to agree on what is most important, what is less important.
- Talk with your family and friends about your work schedule and need for adequate sleep. Make sure they understand that you need to get good sleep to be a good driver and to work safely. Help your family and friends to understand why you need *uninterrupted* sleep, even if you must sleep in the daytime. Work out ways to keep your sleeping area quiet and your sleeping time "sacred." You may have to set up a special place for daytime sleep, in the basement or another place away from noisy activities and light.
- "Let go" of some of the time-consuming activities you have decided are not top priorities. For example, you might find it worthwhile to hire someone to mow the lawn or paint the porch, so you can spend your at-home time with your family. Maybe the yard service or your teenager won't do the job quite as perfectly as you would, but you'll have the time for more important things.
- Try to plan family events for when you are reasonably sure you can be home, and try to keep those commitments. At the same time, help your family to accept the fact that

sometimes they will have to perform their activities without you.

- Keep in touch when you are on the road. Find a good deal on long-distance phone service, and use it. While you're away from home and busy, your family may be feeling "left behind" and may not be able to contact you easily. They'll appreciate hearing from you often and having you participate in family discussions and decision-making.
- If your employer, union, or community organizations offer wellness or family-support programs, give them a try. You may enjoy and benefit from the programs themselves, and you will likely make new friends among people who understand the lifestyle and challenges of your profession.

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Glossary of Terms

The terms defined here occur in course materials to be presented to learners, and do not include all technical words and phrases from the Instructor References. Words contained in definitions that are defined elsewhere in the glossary are rendered in boldface.

acute Developing over a short period of time. Acute fatigue can be repaired by a night or two of solid restorative sleep. See **chronic**.

adaptation The response of the body to any continuing unusual condition, usually resulting in a restoration of the physical status quo. When a driver ingests **caffeine**, the initial effect is **stimulation**; after repeated doses of caffeine, however, the body will adapt and revert to its original state, a change which, among other things, increases the dose of caffeine necessary to re-stimulate.

alertness The relative readiness of a person to receive, recognize, and act on information; the general level of **attention**. One of the effects of **fatigue** is to reduce alertness; a fatigued driver may, for example, miss an exit due to loss of alertness.

alpha waves Electrical activity on the surface of the brain, usually measured by **electroencephalograph**, having relatively low amplitude and in the frequency range 8-13 Hz. Alpha is associated with relaxation, and often precedes and accompanies Stage 1 sleep (See **sleep stages**).

amphetamine Any of a class of powerful stimulants that operate by increasing release of the neurochemicals norepinephrine and dopamine. The result of amphetamine use is an immediate increase in arousal and a pleasant feeling. However, the effect wears off, and is followed by a "rebound" state of depression; large doses can trigger *amphetamine psychosis*. **For these and other reasons, amphetamines are regarded as hazardous and are legally available only by prescription. They are strongly addictive and are classed as "drugs of abuse."**

apnea (Greek: "without breathing") A more or less severe disorder of sleep in which the sufferer experiences episodes during which the airway closes and breathing stops. This results in an increase in carbon dioxide in the blood, and causes the sufferer to awaken, gasping for air. This may occur hundreds of times in a night, and remain unknown to the sufferer. The destruction of quality sleep causes health and safety problems. Apnea can be diagnosed and treated.

attention The general allocation of sensory and perceptual functions to a limited range of inputs. A driver may be paying **attention** to exit signs and other roadway information. **Alertness**, as the term is used here, is a more broad-range readiness to receive any important inputs; we may pay **attention** to exit signs, but be **alert** to possible traffic problems.

barbiturate Any of a class of drugs used as anticonvulsants, sedatives, tranquilizers, and sleep aids. They are now used less frequently than 30-40 years ago because they are strongly habit forming and are lethal in large doses. **They are dangerous when used for purposes and doses other than those prescribed by a physician, and are illegal in other cases.**

benzodiazepines A class of drugs used as sedatives and sleep aids, now regarded as preferable to **barbiturates** because they are less habit forming and less likely to be fatal in large doses. Benzodiazepines include diazepam (Valium), chlordiazepoxide (Librium), alprazolam (Xanax), triazolam (Halcion), and temezepam (Restoral). **Benzodiazepines are available only by prescription, and should not be used except for purposes and in doses prescribed by a physician.**

biological rhythm Many physiological functions are cyclic, with rhythms of widely differing frequency (from the roughly 28-day cycle of menstruation to the approximate 24-hour cycle of body temperature to synchronous brain waves cycling many times a second). Many key functions have a cycle of about a day (**circadian rhythm**).

caffeine A naturally-occurring mild stimulant that affects duration of some nerve transmissions. Caffeine is found in coffee, tea, chocolate, and other commonly available natural food sources and artificial sources like soft drinks and food additives. Caffeine is commonly found in diet pills and other medications, and can be purchased in pill form (e.g., No Doz). Caffeine also influences resetting of the biological clock.

CDL Commercial Drivers License.

chronic Characterized by slow or gradual onset and long duration. Chronic fatigue is the result of circumstances lasting a long period of time (e.g., weeks or months of combat operations) and, unlike **acute fatigue**, can be corrected only by a prolonged rest or vacation.

circadian clock A physiological mechanism that governs the phase and duration of the circadian rhythm. This is a literal “biological clock” centered in the *suprachiasmatic nucleus* of the brain’s hypothalamus. Timing of the 24-hour cycle appears to be based on the decay rate of unidentified proteins, and resetting of the clock is associated with bright light and other biological, physical, and social factors. The “biological clock” also indirectly controls secretion of **melatonin** by the pineal gland.

circadian rhythm A **biological rhythm** of approximately 24 hours (Latin *circa die*, “about a day”) that governs elements of sleep and waking, mood, alertness, secretion of stomach acid, key hormonal cycles (including growth hormone and **melatonin**), and other biological events. The cycle includes a low point in the early morning hours during which many functions are depressed and the body is adjusted for sleep, and a mid-afternoon lull (**postprandial dip**) during which the rise in rhythm briefly levels off. The phase and frequency of the cycle are governed by a **circadian clock**.

cognitive Of or pertaining to the higher mental or intellectual functions, e.g., thinking, reasoning, remembering.

drowsiness The subjective experience of gradually increasing tiredness associated with a condition of sleep loss, low points in the circadian cycle, effects of drugs such as sleeping pills and antihistamines, or other causes. Drowsiness is characterized by subjective desire for sleep, loss of **attention**, high rates of eye blinks and long eye closures, and other events.

electroencephalograph A device used to measure brain waves by placing electrodes on the scalp to measure small, rhythmic changes in DC potential, the result of algebraic summation of millions of nerve impulses on the surface of the brain. The output of an electroencephalograph (EEG) is called an *electroencephalogram*, and may be recorded as line traces on moving paper using ink styluses, recorded digitally, or displayed on a high-persistence phosphor oscilloscope. The sleep stages are recognizable principally by characteristic EEG brain wave electrical patterns of given frequencies and amplitudes.

fatigue ¹An internal state produced by repetitive mental or physical activity, sleep loss, boredom and monotony, excessive task demands, and other factors, characterized by loss of strength, diminished **alertness** and **vigilance**, depression of mood and motivation.

²A set of observable changes in behavior such as slowed response times, decreased alertness, and increased likelihood of errors, brought about by sustained performance, lack of sleep, and other causes.

These two definitions are related, but differ in a subtle but important way: The first is a *construct*: a concept invented for scientific purposes to explain changes in behavior, while the second is the behavioral changes themselves. This is important because the definition we choose has effects on how we study fatigue.

gastrointestinal Of or pertaining to the upper (esophagus, stomach and duodenum) and lower (principally the large and small intestines) digestive organs. **Fatigue** (as well as other stressful conditions) can produce gastrointestinal disturbances such as constipation, diarrhea, and “indigestion.”

general fatigue General or mental fatigue describes the effects of sustained performance on mental activity — **alertness**, **vigilance**, response speed and accuracy — associated with diminished **cognitive** and perceptual performance. General fatigue is distinct from **physical fatigue**, which results from overstressing muscles and tendons through sustained physical effort.

insomnia A general term describing symptoms of a variety of conditions causing inability to sustain normal sleep. Insomnia may be *onset* (inability to fall asleep), *maintenance* (inability to stay asleep, frequent waking), and *termination* insomnia (premature awakening and inability to fall asleep again).

jet lag ¹A disruption in the **circadian rhythm** caused by rapid air travel across widely separated time zones, which may result in sleep disturbance, daytime **drowsiness**, discomfort, a general feeling of malaise, mood changes, and other performance problems. ²The disruption of performance and mood caused by travel across time zones. In effect, the person is shifted artificially in “circadian time” and may have trouble resetting the **circadian “clock”** to a new schedule. The body will generally readjust itself, but adjustment will, as a rule, require one day for each time zone crossed.

lapse ¹A pause, usually brief, in **attention**, **alertness**, or **vigilance** caused by **fatigue**, **drowsiness**, or sustained performance. ²An error of omission — failure through inattention or other performance loss to detect a condition and take appropriate action.

lark A general term for persons who report higher performance early in the daily **circadian cycle**; a “morning person” (from the bird which sings early in the morning). See **owl**.

melatonin ¹A natural hormone secreted by the *pineal gland* which assists in triggering sleep onset and maintaining the **circadian rhythm** and the biological clock. ²A synthetic form of the hormone manufactured for sale as a sleep aid.

mental fatigue See **general fatigue**.

microsleep A brief (typically 3-10 seconds) period of involuntary performance lapse associated with entry into a light sleeplike state. The eyes may remain open during such episodes, but perception and performance lapse. Microsleeps are associated with significant sleeplessness and fatigue.

nap A brief sleep period, usually during the day, to supplement or replace sleep normally obtained at night. For purposes of this program, a short night’s sleep is *not* a nap. Naps are short sleep periods in addition to the normal (even if briefer than usual) night’s sleep.

narcolepsy A severe sleep disorder characterized by sudden onsets of involuntary REM sleep. Narcoleptic seizures often accompany strong emotional changes, and are generally of short duration.

nicotine A chemical present in tobacco which acts as a mild stimulant, increasing heart rate, and arousing parts of the cerebral cortex. Nicotine is not an effective stimulant, and the smoke from a cigarette can increase drowsiness.

NREM Sleep in which the characteristic rapid eye movements (REMs) of active or paradoxical sleep are not present; in effect “non-REM” sleep.

owl A general term for persons who report higher performance late in the daily **circadian cycle**; an “evening person.” See **lark**.

postprandial dip (Latin *post prandium*, “after lunch”) A leveling in the general performance increase associated with the rising part of the daily **circadian rhythm**. This occurs in mid-afternoon, includes a feeling of **drowsiness**, and is often incorrectly attributed to the effects of digesting lunch.

REM Rapid eye movement sleep; a state of light sleep characterized by rapid movements of the eyes (under closed lids) and muscular tonus (relaxation of major muscles). Also called *active sleep* and *paradoxical sleep*, REM sleep is a necessary part of the normal sleep cycle, and typically occurs several times during a night’s sleep. REM sleep is accompanied by dream activity.

rest A period of relaxation or change of activity during a sustained period of work during which sleep does *not* occur — rest simply gives the mind and body a break from some sustained activity. Rest alone cannot restore lost sleep.

RLS (Restless Legs Syndrome) A sleep disorder, more common among older drivers, characterized by a feeling of itching or skin discomfort on the lower limbs and consequent restless movements that disrupt sleep. (Related disorders include *nocturnal myoclonus* and *periodic limb movement disorder* (PLMD)).

shift lag Body cycle changes and performance loss caused by shift changes that disrupt the circadian cycle; similar to **jet lag**. The effects of shift lag are particularly troublesome because the sufferer is continuing to work while fighting the circadian clock.

sleep debt A condition caused by loss of sleep, most particularly cumulative. If an individual’s nominal healthy or preferred daily sleep requirement is 8 hours, two consecutive days with only six hours of sleep will produce a 4-hour sleep debt.

sleep inertia A period of grogginess and low performance immediately after awakening from a period of sleep, particularly after awakening from a nap longer than 45 minutes to an hour.

sleep stages Human sleep proceeds in stages that vary in depth from lightest sleep (stage 1) to deepest sleep (stage 4). These stages are defined by characteristic brain wave patterns.

stimulant A chemical such as **caffeine** that triggers temporary physiological arousal.

SVRD Single vehicle roadway departure: a crash configuration that results when a vehicle drifts off the roadway, generally due to a performance lapse by the driver. SVRD crashes are frequently associated with driver **fatigue**.

vigilance A state in which a person maintains a high level of sensory **attention** (usually visual or auditory) in order to detect a change, as when a driver watches for a particular exit sign. Vigilance differs from **attention** in that it is directed at a more specific range of events.

withdrawal A period of discomfort or low performance that occurs when the effects of a drug

begin to wear off, such as the “rebound” from sleep aids. The effects are due to the body’s **adaptation** to a chemical presence that is no longer present.

